ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 57. No. 10. 220 Broadway, New York, March 7, 1907.

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THE ENGINEERING STAFF OF THE PENNSYLVANIA R. R. HUDSON RIVER TUNNELS.

As a matter of interest in connection with the paper on the Hudson River Tunnels of the Pennsylvania R. R. (the second half of which appeared in our last issue), and supplementing that paper, we present herewith a reproduction of a group photograph of the engineering staff of that enterprise. For the use of this photograph we are indebted to the courtesy of Mr. Charles M. Jacobs, Chief Engineer of the North (Hudson) River Division of the Pennsylvania Railroad's New York City extension work.

An organization diagram of the staff appeared on p. 232, Feb. 28, 1907. The diagram as well as the present photograph include the engineering force of the work from Tenth Ave., New York City, to the Hackensack Meadows portal (west end) of the Bergen Hill tunnels; that is, about a mile of rock cutting and tunnel in addition to the subaqueous work described by Mr. Forgie. The North River Division is subdivided into (1) Terminal Station West, (2) River Tunnels, and (3) Bergen Hill Tunnels, the second group comprising the work between shafts, described in the paper noted.

THE ENGINEERING STAFF OF THE PENNSYLVANIA R. R., HUDSON RIVER TUNNELS; NORTH RIVER DIVISION, PENNSYLVANIA, NEW JERSEY & NEW YORK RY. AND PENNSYLVANIA, NEW YORK & LONG ISLAND RY.

1. Charles M. Jacobs, Chief Engineer.
2. James Forgie, Chief Assistant Engineer.
3. A. J. Loomis, M. D., Chief Medical Officer.
4. H. M. Hewett, General Resident Engineer, River Tunnels.
5. B. F. Cresson, Jr., Resident Engineer, Terminal Station.
6. H. F. D. Burke, Resident Engineer, River Tunnels.
7. Wm. Lowe Brown, Resident Engineer, River Tunnels.
8. C. Lavis, Resident Engineer, Bergen Hill.
9. Jno. C. Naegeley, Chief Metal Inspector.
10. E. Y. Allen, Asst. Resident Engineer, Bergen Hill.
11. J. Soderberg, Mechanical Engineer.
12. J. R. Taft, Assistant Engineer, Bergen Hill.
13. H. E. Boardman, Assistant Engineer, River Tunnels.
14. W. H. Lyon, Assistant Engineer, River Tunnels.
15. J. F. Rodenbough, Assistant Engineer.
16. H. J. Wild, Assistant Engineer, River Tunnels.
17. H. V. Hitchcock, Assistant Engineer, River Tunnels.
18. W. B. Johnstone, Assistant Engineer.
19. J. F. Sullivan, Assistant Engineer, River Tunnels.
20. A. W. Gill, Assistant Engineer, Terminal Station.
21. R. T. Robinson, Assistant Engineer, River Tunnels.
22. E. R. Peckens, Assistant Engineer, River Tunnels.
23. H. W. Hegeman, Chief Tunnel Inspector, River Tunnels.
24. C. D. Thomas, Assistant Engineer, River Tunnels.
25. F. A. Hitchcock, Chief Tunnel Inspector, River Tunnels.

EXPERIMENTS ON MATERIAL FOR COLD SPRINGS DAM, UMATILLA IRRIGATION PROJECT, OREGON.

By D. C. HENNY,* M. Am. Soc. C. E., and E. G. HOPSON.†

The Cold Springs dam forms a part of the works of the Umatilla Project now under construction by the U. S. Reclamation Service.

The lands to be irrigated have an area of 20,000 acres and lie in the vicinity of the town of Umatilla, at the junction of the Columbia and Umatilla rivers in Oregon. The water is obtained from the Umatilla River. The low water flow of this stream is small and has been fully appropriated by private irrigators. Dependence must, therefore, be placed on winter and flood flow, for which reason storage of water is essential. No economical reservoir sites exist on the Umatilla River or its tributaries, but a suitable site was found in a small independent drainage area, immediately adjoining the irrigable lands and draining independently into the Columbia River. This reservoir is formed by the closing of a gap at the outlet of a small valley by means of the Cold Springs dam. It has a capacity of 50,000 acre feet and is filled by a feed canal from the Umatilla River, 25 miles in length and having a carrying capacity of 300 cu. ft. per sec.

The Cold Springs dam is designed as an earth embankment about 3,200 ft. long and with a maximum height of about 82 ft., measured from the surface of the bottom lands to the ordinary high water line. There is also a cut-off extending down to bed rock at a maximum depth of about 30 ft. below the general surface of the ground in the bottom. The embankment will have a 3 to 1 slope toward the water and a 2 to 1 slope on the down-stream side; it will be built without a core wall, and the overflow waters will discharge over a masonry spillway founded on bed rock at the northerly end of the dam. The contents of the dam are about 620,000 cu. yds.

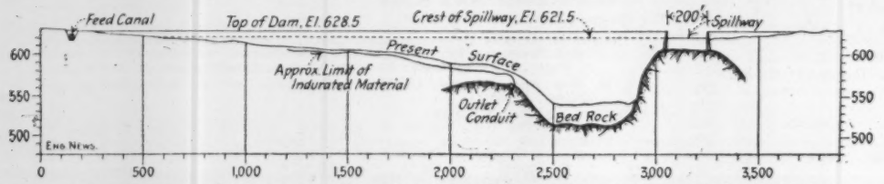


FIG. 1. LONGITUDINAL SECTION OF PROPOSED COLD SPRINGS DAM, UMATILLA IRRIGATION PROJECT, OREGON.

The country rock is a basalt of the ordinary columnar formation, and, so far as observed, is of a dense structure reasonably free from fissures or cracks of any sensible size. This rock appears to be generally overlaid with partially cemented gravel and sands, which, in turn, are overlaid with extensive beds of fine sands, volcanic ash and surface soil, the latter being generally a fine, light soil from 2 to 10 ft. deep. The surface contour has been greatly modified by wind action, and the depth of surface soil varies considerably in different places, depending upon exposure to the prevailing wind. Soil apparently of similar nature to that found on the surface was found at a depth of upward of 20 ft. at one spot near the dam site.

Toward the north end of the dam the material immediately overlying the rock is a species of indurated clay. The basaltic formation or lava flow crops out in bold cliffs near the north end of the dam and also on the southerly side-hill, where it is proposed to build the outlet conduit. About 1,500 ft. below the dam, on the southerly side-hill, there is another outcrop of basalt, and opposite this point, on the northerly side-hill, the formation changes to a coarse sand and gravel deposit which extends for a considerable distance in a westerly direction.

The material that may be considered as immediately available for dam construction is as follows:

(1) The basalt rock, which may be readily blasted and used for masonry and riprap, it being eminently suitable for this purpose.

(2) The gravel deposit on the northerly side-hill below the dam, which is especially suitable for forming a solid nucleus when mixed with other material, or for backing up the down-stream part of the embankment, where no water-tight qualities are required.

(3) The fine surface soil covering practically the entire country and the most readily available for use in embankment.

(4) The deposits of pure volcanic ash, which occur at infrequent intervals and in somewhat scanty quantities.

(5) The indurated clay deposits at the north end of the dam.

(6) The sands and gravels generally underlying the surface soil, and which are, to some extent, stratified and indurated.

The first three mentioned materials are available, however, practically the only ones available for use in large quantities and at reasonable cost. The others may only be obtained after stripping and removing large masses of overlying material or by long and expensive hauls. For other reasons these latter are unsuitable for embankment use, and the feasibility of a dam at this point depends upon the suitability and availability of the first three materials.

At the outset it was assumed, tentatively, that the surface soil possessed qualities that would insure the necessary water-tightness to the dam, by reason of the considerable proportion of fine organic and inorganic matter contained. The gravel was expected to be of especial use for mixing with the soil to obtain solidity and firmness in the mass, and also to form a good drainage for the down-stream slope. The basalt rock was obviously suitable for all concrete and paving. Thus, in a general way, it was decided to form the part of the dam nearest the water slope wholly of soil and possibly to use the same material for filling the cut-off trench. The middle part of the dam was expected to be formed of a mixture of soil and gravel, and the down-stream slope to be of pure gravel. The whole embankment was to be riprapped with the basalt rock.

The results of the experiments have led to a considerable change in this tentative plan of distribution, and the final plan adopted will be found at the conclusion of this paper.

The surface material in the vicinity of the dam is by no means of a regular and uniform character. In some places it is of a markedly coarse texture and resembles rather a sand than a soil. In other places it is found entirely mixed with and blending into layers of white volcanic ash, and again it may be found as extremely light superfine sand, which when dry can be poured almost like a liquid. In no case does it appear to contain any perceptible proportion of clay or to possess qualities of cohesiveness when in a puddled condition.

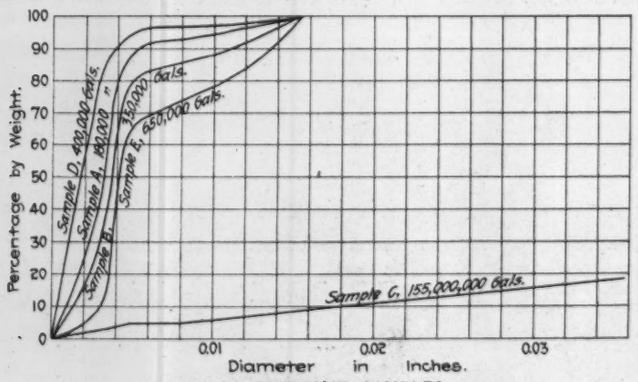


FIG. 2. STRAIGHT SAMPLES.

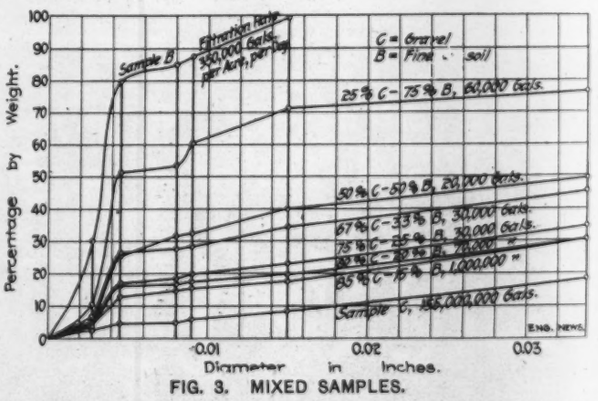

Percentage by Weight.
Filtration Rate 350,000 Gals. per Acre, per Day
Sample B
C = Gravel
B = Fine soil
25% C - 75% B, 60,000 Gals.
50% C - 50% B, 20,000 Gals.
67% C - 33% B, 30,000 Gals.
75% C - 25% B, 70,000 "
80% C - 20% B, 1,000,000 "
85% C - 15% B, 1,000,000 "
Sample C, 155,000,000 Gals.
Diameter in Inches.
Eng. News.

FIG. 3. MIXED SAMPLES.

FIGS. 2 AND 3. SIZING CURVES, OR PERCENTAGES BY WEIGHT, OF MATERIAL OF VARIOUS DIAMETERS IN MATERIALS TESTED FOR PROPOSED EARTH DAM.

(The quantities in gallons are the percolation rates per acre per day as observed on the third day of the tests.)

of material of all kinds, after mixing and compacting.

A longitudinal section of the dam is shown by Fig. 1 and a cross-section by Fig. 9.

The designs of earth dams, so far as the writers are aware, have usually been based upon broad judgment and precedent and upon a general understanding of the nature of the available material. In this manner the Cold Springs dam was designed by a board of engineers consisting of Mr. A. J. Wiley, of Boise, Idaho, and the writers, and the type and dimensions were decided upon as above outlined. In view of the availability of various classes of materials, found at greatly differing distances from the dam, and the desirability of determining the mixtures which would produce the best results at the smallest cost, is was deemed advisable to make a close study of their mechanical qualities, covering more especially the following features:

(a) Specific gravity; (b) sizing curves, with resultant effective size and uniformity coefficient; (c) percentage of voids; (d) rate of percolation.

Samples were selected from the materials above described as available for dam construction, as follows:

Sample A: Soil taken from the upper 12 ins. in the bottom lands near the dam, and selected as being probably the tightest available material in any considerable quantity. In general appearance this soil differs from the deeper-lying soil by being to an almost imperceptible extent darker in color, but containing a sensibly greater quantity of organic matter, such as roots and vegetable fibers. Its puddling qualities, however, are little, if any, superior to the other soils.

Sample B: Soil taken from 1 to 4 ft. below

*Supervising Engineer, U. S. Reclamation Service, Portland, Ore.

†Assistant Supervising Engineer, U. S. Reclamation Service, Portland, Ore.

the surface of the ground. It is slightly lighter in color than Sample A and with less vegetable matter. Its color, when dry, it is a light, grayish brown. It is probably the commonest and most readily available material at the dam site.

Sample C: Coarse sand and gravel from the steep side-hill about 2,000 ft. below the dam line. The mass of this material is a coarse sand or fine

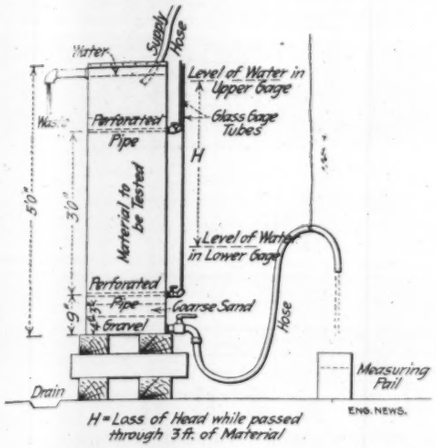


Fig. 4. Filter Tank Used in Testing Materials for Proposed Earth Dam.

gravel, with a considerable proportion of gravel that would be retained on 1-in. mesh; also occasional large cobbles. There is a marked scantiness of fine sand in this admixture.

PHYSICAL CHARACTERISTICS OF MATERIALS FROM SITE OF PROPOSED COLD SPRINGS DAM, UMATILLA IRRIGATION PROJECT, OREGON.

Sample		Specific gravity: Constituents.	Specific gravity: Mass.	Percentage voids: Dry, Loose.	Percentage voids: Dry, Compact.	Percentage voids: Wet, Rammed.	*Uniformity coefficient.	*Effective size, mm.	Rate of percolation, gals. per acre per day	Nominal velocity of percolation in feet per day, determined by dividing section into quantity.
A	Surface soil....	2.52	1.75	59	49	44	3.9	0.023	180,000	0.55
B	Fine subsoil...	2.65	1.55	54	43	45	4.0	0.025	360,000	1.07
C	Gravel	2.90	1.91	42	37	34	9.2	0.550	155,000,000	476.
D	Volcanic ash..	2.66	1.94	74	68	65	5.5	0.010	400,000	1.23
E	Coarse subsoil.	2.93	1.57	55	49	46	1.5	0.079	650,000	2.00
	Mixtures.									
B	C									
75%	25%	2.64	1.75	50	39	38	3.0	0.066	60,000	0.18
67%	33%	2.83	1.76	47	41	39	...	.....	30,000	0.09
50%	50%	2.90	1.91	42	33	34	14.7	0.076	20,000	0.06
33%	67%	2.87	1.95	41	35	32	20.0	0.076	30,000	0.09
25%	75%	2.83	2.01	47	43	29	21.0	0.086	30,000	0.09
20%	80%	2.91	2.04	47	40	30	76.7	0.091	70,000	0.22
15%	85%	2.84	1.88	41	35	34	18.0	0.102	1,000,000	3.07

*Mass. State Bd. of Health standard.

dam site at a depth of 1 to 4 ft. It is appreciably coarser in appearance than Samples A and B, but otherwise greatly resembles those samples in general qualities. It is one of the commonest materials in the vicinity.

Samples A, B and E are probably fairly representative of the soils encountered in this section of the West. They all contain a considerable proportion of volcanic ash and vegetable matter, consisting, to a large extent, of sage roots. The proportion of this latter ingredient is surprisingly large, especially in Sample A, and there is no doubt that it is a considerable factor in influencing the rate of percolation.

The sizing curves are shown for each sample of material in Fig. 2, and for various mixtures in Fig. 3. The specific gravity, voids, uniformity coefficient and effective size are given in the table above.

loss of head, determinations were made under smaller heads.

The tanks were of galvanized iron, 18 ins. in diameter and 5 ft. deep (Fig. 4). They contained horizontal perforated pipe 3 ft. apart, vertically, connected with glass gage tubes. The material to be tested was carefully rammed, in a wet condition, into the tanks between and around the perforated gage tubes, and, to prevent any possibility of the seepage of water along the sides of the tanks, the interiors of the tanks were painted and sanded. Water was maintained at a constant head, and the discharge from the outlet at the bottom of the tanks was regulated by raising or lowering the latter until the required adjustment was made. The level of water in the gages showed the head or pressure at each of these points, and the difference between the levels of the upper and lower gages showed the

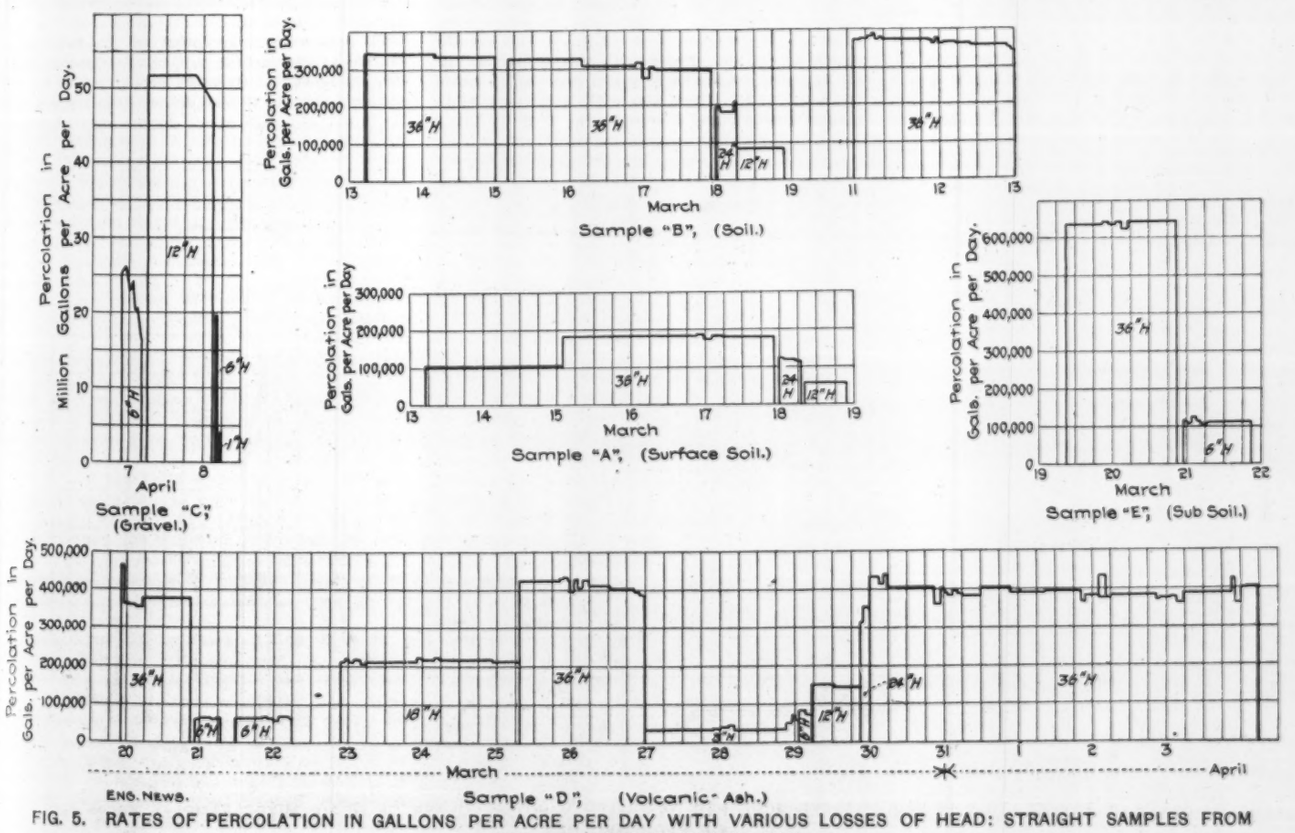


FIG. 5. RATES OF PERCOLATION IN GALLONS PER ACRE PER DAY WITH VARIOUS LOSSES OF HEAD: STRAIGHT SAMPLES FROM SITE OF PROPOSED EARTH DAM.

(Rates corrected for a temperature of 50° F. H = loss of head.)

Sample D: Volcanic ash obtained from a considerable deposit below the dam site. It also occurs in smaller quantities throughout the area near the dam. It is generally almost pure white in color, and when in place appears to be slightly indurated. When loosened it greatly resembles wheat flour in color, lightness and silkiness of feel. It has no puddling qualities.

Sample E: A coarse soil obtained near the

The next to the last column of this table shows rates of percolation through 3 ft. of various materials and mixtures, with a loss of head of 3 ft., expressed in gallons per acre per day. These rates were determined by placing the materials in tanks similar to those used by the Massachusetts State Board of Health and the Massachusetts Metropolitan Water Board. In addition to standard experiments with 3 ft. head lost in friction incident to passing through the intervening 3 ft. of material. The quantity flowing from the outlet was carefully measured by weight at freqeuent intervals, and ordinarily the flow was adjusted so that a 3-ft. loss of head was attained.

Results of experiments with straight samples of material are shown in detail in Diagrams Fig. 5, corrected to a basis of 50° temperature of ap-

plied water by using the formula of the Massachusetts State Board of Health, 1892.

A casual comparison of the sizing curves (Fig. 2) with the rates of percolation for the corresponding materials shows that their relation is irregular and uncertain.

terminations alone. Probably one of the most influential factors in determining the porosity of the soils and ash is the contained vegetable matter, which is noticeably greater in Sample A, the most water-tight of these materials, and is almost absent in Sample D.

of the Metropolitan Water-Works, Massetts (Clinton, Mass.). According to the comparison the eastern soils are somewhat water-tight than Samples A, B and E, but to any marked extent.

The loss of head being in direct proportion to

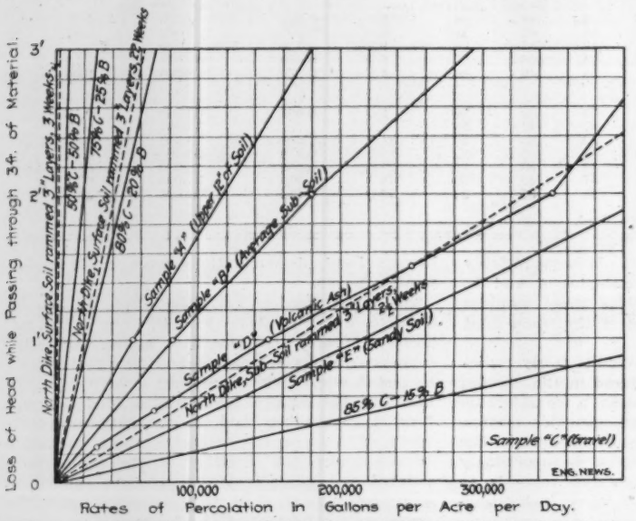

Loss of Head while Passing through 3d. of Material.
3'
2'
1'
0
North Dike, Surface Soil rammed 3" Layers, 3 Weeks.
North Dike, Surface Soil rammed 3" Layers, 2½ Weeks.
North Dike, Sub-Soil rammed 3" Layers, 2½ Weeks.
50% C - 50% B
75% C - 25% B
80% C - 20% B
Sample "A" (Upper 2'-0" of Soil)
Sample "B" (Average Sub-Soil)
Sample "D" (Volcanic Ash)
Sample "E" (Sandy Soil)
85 % C - 15 % B
Sample "C" (Gravel)
ENG. NEWS.
100,000
200,000
300,000
Rates of Percolation in Gallons per Acre per Day.

FIG. 6. COMPARISON OF RATES OF PERCOLATION IN GALLONS PER ACRE PER DAY: SAMPLES FROM PROPOSED DAM SITE AND FROM SOIL AT NORTH DIKE, METROPOLITAN WATER-WORKS, CLINTON, MASS.

(The rates are those observed on the third day of the experiments.)

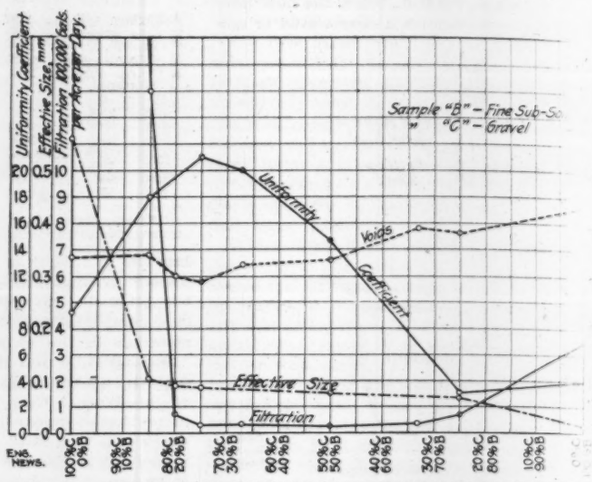


FIG. 8. MECHANICAL PROPERTIES OF VARIOUS MIXTURES OF POSSIBLE MATERIALS FOR CONSTRUCTING PROPOSED COLD SPRINGS DAM.

TESTS OF NATURAL OR UNMIXED MATERIALS.

The effective size probably corresponds more closely with the filtration rates than the other determinations, but there is an important exception in the case of Sample D (volcanic ash), which, however, may possibly be explained by the large

It has been well established that percolation of water through sands and gravels is in a direct ratio to the head lost by friction. To still further confirm this theory, the flows in the tanks were adjusted for different losses of head, with results which are in conformity with this principle. In all of these diagrams showing percolation rates the head under which the tank was operated is plainly marked, and a comparison of these heads

the velocity of percolation, it is evident that the total percolation through any thickness of material will be equal to the ascertained rate of filtration of the material, multiplied by the head and divided by the thickness or depth of the material. Of the three soil samples and the volcanic ash which were used in the experiment, Sample A, the surface soil, is the tightest, probably by reason of its large proportion of organic matter. Sample B also shows a fairly satisfactory rate, although about double that of Sample

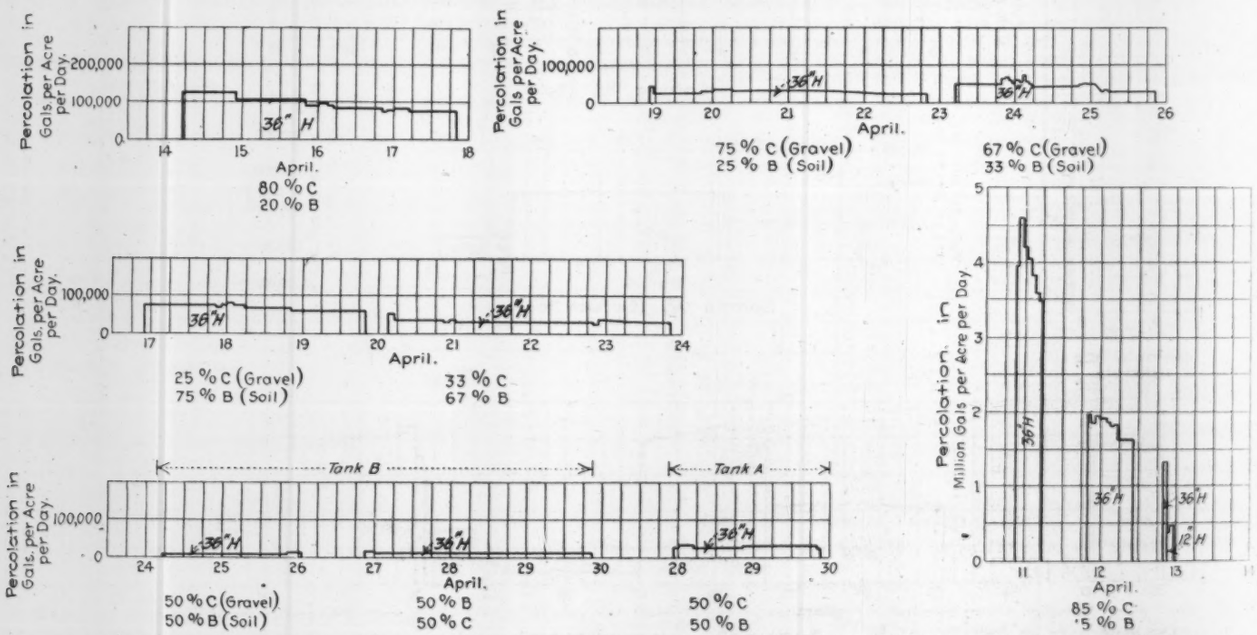


FIG. 7. RATES OF PERCOLATION IN GALLONS PER ACRE PER DAY WITH VARIOUS LOSSES OF HEAD: MIXED SAMPLES FROM SITE OF PROPOSED DAM.

(The lines show rates corrected for a temperature of 50° F. H = loss of head.)

proportion of voids in the latter. In general, a low effective size and high uniformity coefficient should be a pretty sure indication of a small rate of filtration, and of these, the former is by far the more important. The proportion of voids is of little value in itself as an indication of the permeability of the material, as illustrated in the case of Sample C, but it may be useful to qualify an estimate based on the other two de-

will show that in almost every case the rate of percolation is in direct proportion to the head. Fig. 6 especially illustrates this principle by showing that plots of the various percolation rates and the corresponding losses of head for each material approximate very closely to straight lines. This diagram also shows an interesting comparison between these soils and some eastern soils used in the construction of the North Dike

A, and even Sample E, the coarsest of these three, shows a comparatively low rate, although nearly twice that of B and four times that of A. On the other hand, Sample D, the volcanic ash, although containing a much greater proportion of fine matter than either of the others, yet had a rate greater than Samples A and B, probably due to the almost complete absence of vegetable matter. Sample C (gravel) offers little

resi[illegible]nce to passage water, its rate being 1,500 tim[illegible]lat of A.

T[illegible]m a clear idea of what the loss by seepage [illegible]ough a dam of the size of the Cold Springs dam [illegible]ould be if the embankment were built wh[illegible] of any of these materials (excepting the gra[illegible] and seepage below the ground surface be[illegible]egarded, the following figures may be of [illegible]ice:

built of A — 68,400 gals. per day;
" " B — 133,000 " " "
" " D — 152,000 " " "
" " E — 247,000 " " "

Th[illegible] figures show that as regards actual quantity [illegible] water lost any of these soils would form a r[illegible]onably satisfactory barrier.

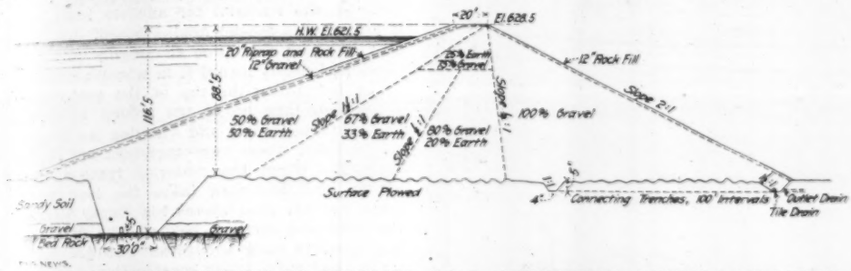


FIG. 9. MAXIMUM SECTION OF PROPOSED COLD SPRINGS DAM, UMATILLA IRRIGATION PROJECT, SHOWING DISTRIBUTION OF MATERIALS DECIDED UPON AS A RESULT OF EXPERIMENTS.

The three soils, A, B and E, when dry absorb moisture with avidity, and when water is added the whole mass becomes quickly permeated with a fair degree of uniformity. When the proportion of added water does not exceed in volume about 75% of the voids these materials may be compacted in a very satisfactory manner and form a good solid mass. The proportion of voids, however, even when the material is very carefully rammed, is still very high (41 to 46%), and the specific gravity of the mass is rather low. A small surplus of moisture renders the mass very soggy and difficult or impossible to consolidate to the same extent as with less moisture, so that an excess of water during consolidation is positively injurious to a bank of this material, and, moreover, there is an unmistakable tendency for these soils, when supercharged with water, to become unstable, and, in certain cases, almost semi-fluid. After several days' submergence it was possible to thrust a thick stick readily through these samples with but little resistance. A bank built of this material exclusively might be in danger of sloughing on the back slope unless the latter were very flat.

Sample D (volcanic ash) does not absorb water with the readiness of the three soils. After being well rammed into the tank it presented an especially hard and solid appearance, but the proportion of voids was as high as 65%. After submergence for several days a stick could be readily thrust through the material, and when the tank was emptied the material could be almost baled out, being in a semi-fluid condition. It possessed no puddling qualities and had a low specific gravity in mass.

Sample C (gravel) although of no value as a retardent to flow, yet possesses qualities of solidity and weight lacking in the other materials. In itself it forms a compact and rather unyielding mass with about one-third voids, but lacking in all binding qualities.

The percolation experiments were continued by mixing soil (Sample B) and gravel (Sample C) in different proportions. The detailed results of these tests are graphically shown on the diagrams composing Fig. 7. Figs. 3 and 8 show comparisons of the percolation rates, the sizing curves and other data.

TESTS OF MIXED SAMPLES.

The proportions in which the mixtures were made were regulated by measure, the materials being fairly well compacted into the measures. The supply being limited, it was necessary to use the same material over again in the series of experiments with different mixtures. Two tanks were in operation, and at the beginning of the series one was filled with Sample C and the other with Sample B; after running each tank for a few days they were emptied and recharged, additional new material being added at each recharging to obtain the desired proportions. This procedure necessitated the materials being mixed in a wet condition, therefore the admixture was probably not of so intimate a nature as if the mixing had been dry. In mixing the ingredients they were spread in thin layers on a concrete floor and raked and shoveled some four or five times until the results appeared to be satisfactory. However, in spite of all precaution, the wet soil would, to some extent, ball up and keep separate from the gravel. In measuring the proportions of the two materials no attempt was made to carry out details with the exactitude of laboratory work, but the mixing was unquestionably made with greater precision than is possible in construction work on a large scale.

The mixture of 85% gravel and 15% soil shows a rate of percolation commencing at a high figure but rapidly dropping during the first two days. The curve (see Fig. 6) shows a strong tendency to flatten out at a rate of about 1,000,000 gals. per acre, which has been assumed as the rate for this mixture. The small proportion of soil added to the gravel in this mixture is insufficient to materially alter the general characteristics of the latter, and the resulting mass has little or no binding qualities in spite of a thorough ramming. A thick stick may be worked by hand entirely through the mass without apparently any greater resistance than would be caused by the unmixed gravel.

The difference between the above mixture and that containing 75% gravel and 25% soil is marked and apparently out of all proportion to what would be expected from the addition of such a small proportion of soil to the last described mixture. The rate of percolation is reduced from 1,000,000 to 70,000 gals., which is a smaller rate than was obtained from any of the unmixed samples, and the mixture possesses fairly good binding qualities, forming a solid mass that offers great resistance to any attempt at penetration.

The 50% mixture gave the best results from the point of view of percolation, one of the tanks showing a rate of less than 10,000 gals. per acre, and the other (filled with a similar mixture) about 30,000 gals. This rate was so low that suspicions were aroused as to possible error, but the most scrupulous examination failed to disclose any leakage or other source of error in measurement. The quantity of water flowing from the tank with this low rate was only about one drop every six seconds.

All the mixtures from 75% gravel down to 25% gravel gave very satisfactory filtration rates, but the latter mixture is not wholly satisfactory from the point of view of firmness and solidity, it being inclined to be soggy and soft, and partaking too much of the character of Sample B, of which it was chiefly composed. The mixture of 33% gravel, while manifestly firmer and more compact than the 25% mixture, is yet unequal to the 50% mixture in these qualities.

Figs. 3 and 8 show comparisons of the various mechanical analyses and other determinations of the mixtures of soil and gravel together, with their corresponding percolation rates. An inspection of Fig. 3 shows how slight differences in the proportions in a mixture produce correspondingly slight changes in the sizing curves, while percolation rates may change abruptly, a difference of 5% in soil reducing the rate of one mixture from 1,000,000 to 70,000 gals. per acre per day.

The great reduction in filtration rates caused by the addition of coarse sand and gravel to the fine soil is difficult to explain satisfactorily. The rate for Sample B (soil) is about 350,000 gals. and for mixtures of soil and gravel about 30,000 gals., or only about one-twelfth of the former. The voids in the mixtures are considerably less than in the unmixed soil, being about 30% to 35% in the former against 45% in the latter, which will account for a reduction of rate of about 5%, equivalent to a reduction from 350,000 to about 230,000 gals. The remainder of the reduction of rate from 230,000 to 30,000 gals. must be attributed in part to the greater indirectness of flow through the interstices of the mixed material than through the unmixed and more uniform material.

In applying the results of these experiments to the design of the Cold Springs dam it appears that the tightest and most satisfactory material for placing next to the water line is a mixture of 50% soil and 50% gravel, and that in passing into the interior of the dam the percentage of gravel may to advantage be gradually increased until well past the middle of the dam the percentage of the gravel becomes 100. Accordingly proportions for materials have been adopted as indicated in Fig. 9. The lines of demarcation should be understood to be center lines of merging zones. The material denominated "earth" in Fig. 9 corresponds with the test Sample B, and that marked "gravel" is the same as Sample C.

An estimate has been made of the probable leakage through the dam from water surface to bed rock, which indicates that the aggregate leakage with full reservoir may be about 20,000 gals. per day, or less than 1/30 cu. ft. per sec., a quantity barely sufficient for the irrigation of three acres of land. Less than one-half of this is figured to pass through the embankment proper above the old ground surface.

The writers believe that definite knowledge of the character of materials, which must be utilized in the construction of an earth dam, is highly desirable and can be logically utilized in the design. In the case of the Cold Springs dam it has led to a decided change in the contemplated distribution of the material, and it is believed that thereby a marked improvement has been effected, at no extra cost, in the stability and tightness of the structure.

SMOKE INSPECTION AT ST. LOUIS during 1906 has been reported on by Mr. John Kraus, Supervising Engineer. Mr. Kraus states that "the improvement in smoke conditions" during the year "has been marked." A number of plants have been equipped with gas engines, others have adopted electrical power, and still others have been shut down on account of taking steam from central heating stations of the lighting company. The extension of these steam lines, it is expected, will be continued during this year throughout the down-town section of the city. There are now in use in St. Louis nearly 800 mechanical stokers and more than 400 "automatic smoke preventing devices." Regarding the mechanical stokers, Mr. Kraus states:

We find, however, a disposition on the part of the firemen to handle these stokers carelessly and to allow the steam jet devices to get out of order so that the full value of these devices is not obtained. A canvass of one of the manufacturing sections of the city shows that out of 24 plants equipped with mechanical stokers 3 were operated in such a manner as to entirely eliminate the smoke; 11 plants were doing fairly good work, while 10 were run apparently without any regard to the abatement of smoke. The operating engineers and firemen in these plants have been notified that unless their plants show a decided improvement, Section 5 of the Smoke Ordinance, which makes the person having charge of the feeding or stoking of any steam boiler or furnace equipped with proper smoke preventing devices responsible, will be enforced.

A census of manufacturing plants of St. Louis shows a total of about 231,000 HP. in use, exclusive of heating plants, requiring an estimated quantity of 10,000 tons of coal per working day. Reference is made in the report to a convention of municipal smoke inspectors held at Detroit in June, 1906, at which there were representatives from 17 cities in the United States and Canada and a total attendance of about 60. A permanent organization was formed to meet at Milwaukee in 1907.

PROGRESS OF WORK IN LOWERING THE TUNNELS UNDER THE CHICAGO RIVER.

By WM. ARTINGSTALL.*

The Federal Government, in connection with its river and harbor improvement work, has required a 26-ft. depth in the Chicago River instead of the 17-ft. depth heretofore maintained. This necessitates the lowering of the three street railway tunnels under the river at Van Buren, Washington and La Salle Sts. The Van Buren St. tunnel will be lowered in toto and used for electric traction, whereas the roofs only of the other two will be lowered and the tunnels temporarily closed. The proposed scheme of work was described in detail in Engineering News, Sept. 13, 1906.

The lowering of these tunnels is now well under way and except, as noted below, no accident has occurred nor trouble been encountered. The work is being done for the Chicago Union Traction Co. under the plans and specifications prepared by Mr. Saml. G. Artingstall, M. Am. Soc. C. E., assistant to Chief Engineer. Mr. Artingstall has recently left the service of the company and the position is now held by Mr. James Z. Murphy.

The Van Buren St. tunnel is the private property of the Chicago Union Traction Co., while the Washington St. and La Salle St. tunnels are owned by the city of Chicago, but are being lowered by the traction company under an agreement made with the city. Under this agreement the plans and specifications for the two latter tunnels were approved by Mr. John Ericson, City Engineer. Robt. W. Hunt & Co. are the inspectors for the material and work on all three tunnels.

VAN BUREN ST. TUNNEL.

This tunnel was built in 1889-92 by the West Chicago Street Railway Tunnel Co., of which Saml. G. Artingstall was Chief Engineer, and is one of the largest railway tunnels in the country. It is a three-center arch of brick masonry, 30 ft. wide, 20 ft. high and 1,502 ft. between portals. The west 500 ft. is directly under the Pennsylvania Railroad freight and passenger yard, and the east 300 ft. support two eight-story buildings.

This tunnel is to be completely remodeled so as to be immediately available for street car traffic. The new roof will be 10 ft. below the present one, while the walls will be underpinned and the invert lowered sufficiently to give 14 ft. clear headroom from the new track level.

The new roof of the river section is composed of fifty-three 32-in. steel girders resting on 15-in. 80-lb. I-beam columns spaced 4 ft. 3 ins. c. to c., with concrete jack-arches between the girders. These jack-arches are of concrete, 1:2:4 mixture, and will have a crown thickness of 15 ins. Over this will be a waterproof cover consisting of vitrified brick, laid flat, imbedded in hot asphalt and on top of this will be an 8-in. course of concrete reinforced with a wire netting of about 3-in. mesh.

CONSTRUCTION.—The I-beam columns are set in niches cut in the existing arch of sufficient depth and width to accommodate the bed plate of the column and base plate of the girder. The width of niches in all cases was about 2 ft. and the depth at the base of the columns 20 ins., while at the top of the girder they extended into the arch from 3 to 4 ft., depending on the position where the new roof touched the present arch. This varying depth was caused by the fact that the grade of the present arch and the new roof is not parallel.

The niches for all the columns were cut before any steel work was delivered. When the girders had arrived they were shoved into the niches and jacked up sufficiently to set the columns. The two were then bolted together and brought to an even bearing. When all the girders were set, the niches were faced with sheeting and the columns were concreted in place.

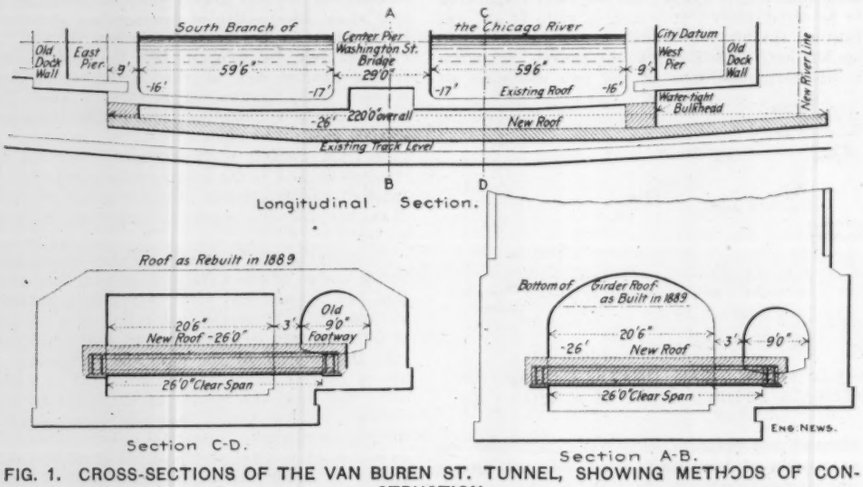


FIG. 1. CROSS-SECTIONS OF THE VAN BUREN ST. TUNNEL, SHOWING METHODS OF CONSTRUCTION.

(Reproduced from Eng. News, Sept. 13, 1906.)

The bottom of the new roof is about 6 ft. above the present floor of the tunnel, so all concrete was mixed below and hoisted to the roof and wheeled to place. Approximately 10 000 cu. yds. of concrete are required to complete each jack-arch.

The organization of the contractor's force is practically perfect, and in spite of the cramped space and number of men employed there has been no friction between them. For example, the concrete gang is composed of five parts, each with its own work. Four men are employed to bring up and spread the sand and cement; this is then thoroughly mixed dry by four others, the first four in the meantime bringing up the crushed stone, which they spread, and then return for the material for another batch, which is placed on a second mixing board. The second four have by this time thoroughly mixed their batch and partly loaded it in wheelbarrows ready to be hoisted to the top of the roof. Two of these men then go to the second batch, while two continue loading and wheeling the first batch to the hoist, where two other men are kept continually. When the material reaches the top of the roof one man takes the load to place while another man leaves his empty barrow on the hoist and sends it below. The fifth part of the concrete gang are those who are stationed at the jack-arch under construction, and who do nothing other than place and tamp the concrete. Owing to the short height (10 ft.) and the cost of operating a power hoist, the contractors rigged up a common windlass and platform elevator which is elevated and unloaded in from 15 to 20 seconds. As it takes about 45 seconds to load, raise and unload a wheelbarrow from the hoist, and practically the same length of time to carry, dump and return with an empty barrow, it is easily seen that no time can be wasted by either the men on top or below the roof without throwing the whole gang out of order. The mixing and placing of the concrete in the jack-arches cost approximately $1.85 per cu. yd.

The Great Lakes Dredge & Dock Co. is the contractor, and Mr. Thos. Osborn their superintendent on this work.

WASHINGTON STREET TUNNEL.

The work at present under contract and about half completed consists in building a new roof and removing the old roof of the tunnel, together with the center pier of the present Washington

FIG. 2. VIEW IN VAN BUREN ST. TUNNEL, SHOWING IN FOREGROUND NICHES CUT FOR RECEPTION OF I-BEAM COLUMNS AND IN BACKGROUND THE NEW ROOF GIRDERS.

*Principal Assistant Engineer in Charge of Tunnel Lowering, Chicago Union Traction Co.

St. bridge, which rests upon the old tunnel roof. The old tunnel consisted of a double-track roadway 18 ft. wide and a 10-ft. passageway separated from the former by a masonry wall 3 ft. thick. The new roof is built to give a clear roadway of 26 ft., measured from the present north wall, which forms the north foundation for the girders. The south foundation runs approximately along the center line of the foot passage.

CONSTRUCTION.—The first work done at this tunnel was to clear out the old foot passage and build the south foundations so that they could be well set before placing the girders. On digging a test pit here it was found that the foundation walls of the tunnel were about 3 ft. higher than shown on the original plans, so instead of there being 3 ft. of solid masonry floor on which to build the foundation, there was only 6 ins. This necessitated the building of the new foundation extending several feet below the base of the old wall, which was only 12 ft. below the bed of the river. The work was, however, successfully prosecuted in short sections, the excavation being done in the morning, and each section of the concrete foundation completed the same day.

The next step was to cut out the partition wall which forms the south support of the roof of the present 18-ft. tunnel. This wall was in bad condition for a greater part of its length, so openings were cut every 16 ft. large enough only to admit a girder. (See Fig. 4.) These openings were securely braced and wedged every night. Similar precautions were taken with the north wall. When the girders were delivered, the east one was placed first and cutting was immediately started for the next, so by the time the first girder was set in place, and the wall wedged above it, the opening for the next girder was ready. This procedure was carried on successfully from beginning to end and no settlement of any kind has been found. The setting of the girders was a slow and awkward job on account of this wall, which is at about the south third of the girder. It necessitated the shoving of the south end of the girder as far as possible into the foot passage and at about 70° with it, then swinging the north end until opposite its opening and finally bringing the girder north to position. The girders are 30 ft. long, 33 ins. deep and weigh approximately 4½ tons. They are set 4 ft. c. to c.

Between the girders jack-arches will be built of a 1:2:4 concrete. These jack-arches will have a thickness of 8 ins. at the crown. A course of waterproofing consisting of vitrified bricks laid in asphalt and covered with a course of 1:3:6 concrete will form the top of the roof. Bulkheads will be built at either end (the east one directly under the present east dock and forming part of it) 10 ft. thick and firmly bonded into the old arch of the tunnel. The removal of the old tunnel roof and the center pier of the Washington St. bridge is to be done without the aid of explosives of any kind and will probably prove the most interesting part of the work.

Angus Bros. & Co. are the contractors for the work at this tunnel, and Mr. Paul Wooster is their superintendent.

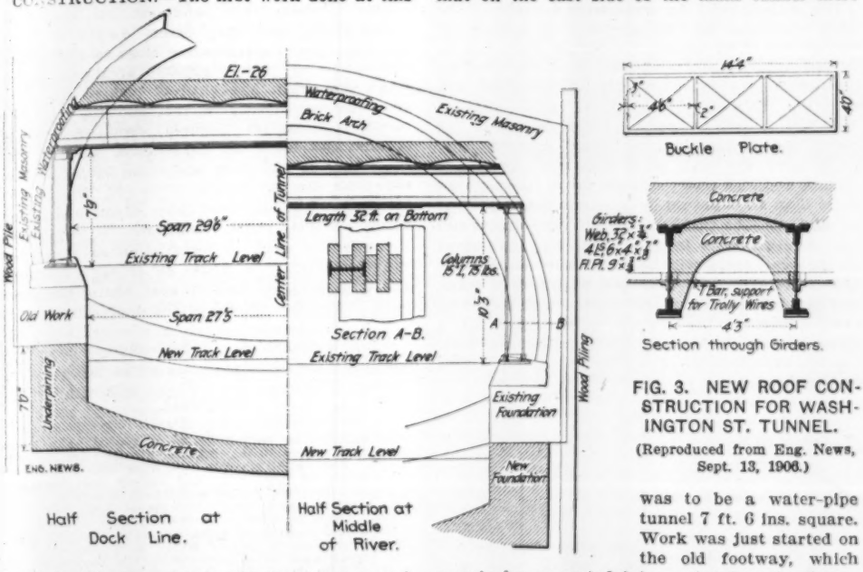


FIG. 3. NEW ROOF CONSTRUCTION FOR WASHINGTON ST. TUNNEL.

(Reproduced from Eng. News, Sept. 13, 1906.)

The next work was to be done on the old tunnel roof and the center pier of the Washington St. bridge is to be done without the aid of explosives of any kind and will probably prove the most interesting part of the work.

Angus Bros. & Co. are the contractors for the work at this tunnel, and Mr. Paul Wooster is their superintendent.

LA SALLE ST. TUNNEL.

This tunnel was to be remodeled in a similar manner to the Washington St. tunnel, except that on the east side of the main tunnel there was to be a water-pipe tunnel 7 ft. 6 ins. square. Work was just started on the old footway, which was to be converted into a pipe tunnel, when a leak developed at about the springing line of the arch and 15 ft. in from the south dock line. This was followed on Nov. 29 by a sudden break in the floor of the footway, about 20 ft. within the dock line. Through the latter the water rushed at about 2,000 gallons per second, and completely flooded the tunnel. It is supposed that the water entered through the old masonry dock wall, which is in bad condition, and followed along the walls of the tunnel. Attempts were made to stop the leaks by calking inside and by depositing clay dredged from the river against the outside of the dock wall. The work is now, however, temporarily abandoned and as yet no plans have been made toward carrying it on.

It is but just to both engineer and contractor to state that there are no plans of the present tunnel in existence, and the actual conditions of the work were quite different from those anticipated. John P. Agnew was contractor for the work at this tunnel.

The article in Engineering News of Sept. 13, 1906, referred only to the 36-in. water main in the old footway of the tunnel at La Salle St., but this was only one of the many utilities to be provided for in reconstruction. On one side of this main was a gas main, while on both sides were the cables of the Chicago Union Traction Co., the Chicago & Oak Park Elevated Ry., the Northwestern Elevated Ry. and the Chicago Telephone Co. Above these were two tubes of the Pneumatic Postal Tube Co., and cables of the Postal Telegraph Cable Co., Chicago Edison Co., Chicago Telephone Co., Chicago Protection Co. and the Chicago & Milwaukee Telegraph Co. It will be seen that a great deal of preliminary work was necessary for taking care of all this mass of important pipes and cables. In addition to this, there were directly under the railway tunnel a 7-ft. city water tunnel and a cable tunnel of the Chicago Edison Co. (of horseshoe section 7'8" × 7'8" ins.). The 36-in. main was slung by 1-in. cables from pairs of 8 × 12-in. timbers, the timbers being about an inch apart to admit the cables between them. Above these are temporary racks for the electric cables. These cross timbers and racks are placed at intervals of about 8 ft. This construction is shown in Fig. 5. It may be noted that some of the cables carried current of 5,700 volts.

AUTOMATIC ELECTRIC BLOCK SIGNALING ON THE BOSTON & MAINE RY.

The Boston & Maine Ry. has taken up the matter of block signaling on its system very vigorously, and some time ago we noted that it had placed a contract for all the material necessary for the equipment of about 1,000 miles of track with automatic electric block signals. From Mr. Frank Barr, Third Vice-President and General Manager, we learn that the company has now in operation, under erection and under contract double-blade electric semaphore block signals for 615 miles of road; 530 miles of this are double track, making 1,145 miles of track in all. The apparatus under the recent contract is supplied by the Union Switch & Signal Co., of Swissvale, Pa., but the lanterns and roundels (or colored lenses) are furnished by the railway company. The installation is also done by the railway company with the forces of its own signal depart-

FIG. 4. VIEW IN WASHINGTON ST TUNNEL, SHOWING METHOD OF SUSTAINING 3-FT. PARTITION WALL DURING CONSTRUCTION OF NEW ROOF.

ment. This work is under the direction of Mr. John V. Young, Superintendent of Signals, and we are indebted to him for particulars of this extensive and interesting work. For the mileage noted above there will be about 1,628 block signals, distributed as shown by the following table, and the estimated cost is about $1,250,000:

	Miles.	Blocks.
Western Division: East Somerville to Maine Central Ry Junction	112.77	300
Medford Branch	1.81	4
Lowell Branch	6.92	18
Eastern Division: N. Beverly to Scarboro Crossing	84.00	222
Saugus Branch, Everett Jn. to West Lynn	9.63	26
Gloucester Branch, Beverly Jn. to Magnolia	8.64	22
Southern Division: E. Cambridge to Concord, N. H.	72.26	192
Woburn Loop, Winchester to N. Woburn Jn.	6.80	16
Lexington Branch, Somerville Jn. to Lex.	8.20	22
Fitchburg Division: W. Cambridge to Mechanicsville and Crescent to Rotterdam Jn.	195.49	516
Watertown Branch, W. Cambridge to Waltham	6.48	18
Troy Branch, Johnsonville to Troy	16.23	44
Worcester, Nashua & Portland Division	18.14	48
Concord & Passumpsic Division	36.90	96
Vermont Valley Ry.	14.43	38
Sullivan County Ry.	17.40	46
Total	614.26	1,628

The Boston & Maine Ry. has for some time contemplated the equipment of its entire system with automatic block signals of the electric double-bladed (home and distant blades) type now in such extensive use on a number of railways. There are at present on the busy sections of the line block signals of different types: manual controlled, telegraph block, electric automatic target and electric automatic disc. All of these, however, will be replaced by the new standard system. The work has been going on for some time, and a large number of signals of the new type have been installed, replacing target and disc signals, which in their day were considered the best that could be devised, and which have faithfully performed their work, but did not convey to the approaching engineman the complete knowledge conveyed by the double-bladed automatic semaphore signals.

This railway has a large system, consisting of a number of main lines with branches. Part of the main lines are double track; and as it was decided to first equip the double track where traffic is congested, this required a large number of signals to start with. In the installation of the signals it is intended to first equip all the double track, then the congested single track, followed by the down-grade single track and finally to complete the entire system.

The new signals, as already noted, are of the double-bladed automatic semaphore pattern, with home and distant signals on the same post. This is the well-known system whereby the engineman is advised two blocks in advance as to the condition he may expect to find in the block he is approaching. The apparatus will be operated on the wireless circuit where possible, and the majority of instruments contracted for will be of the Union Switch & Signal Co.'s make. The semaphores stand normally at the "clear" or "proceed" position. The upper blade gives the indication for the block beginning at the signal, and is painted red with a white stripe. The lower blade gives the indication for the next block beyond (being the distant signal for that block); it has a notched or forked end and is painted yellow, with a black horizontal V, conforming to the forked end. For night indications, the upper (home) signal shows a green light when the blade is inclined 70° to indicate "clear," or a red light when it is at the horizontal position to indicate "stop." The lower (distant) signal shows a green light to indicate "clear" for the second block, or a yellow light to indicate "caution, proceed under control," when the arm is at the horizontal position, the second block being occupied.

The signals will be automatically set at the "stop" position by the presence of a train or car in the block section, or by an open switch, broken rail, open drawbridge, etc. An engineman finding a "stop" signal against him will stop his train at a block-limit post (marked "Block") placed before the signal post. If the signal does not change to "clear" after waiting 15 seconds, the train may then enter the block section and run under control (at a speed of not more than six miles an hour on curves), expecting to find an obstruction. Should the train run into one which is in the block, the engineman of the rear train will be held fully responsible. When there is more than one engine to a train, the engineman on the first engine will blow two short blasts of the whistle to indicate that a signal indicates "proceed," but must not pass the signal unless the rear engineman replies by a similar whistle.

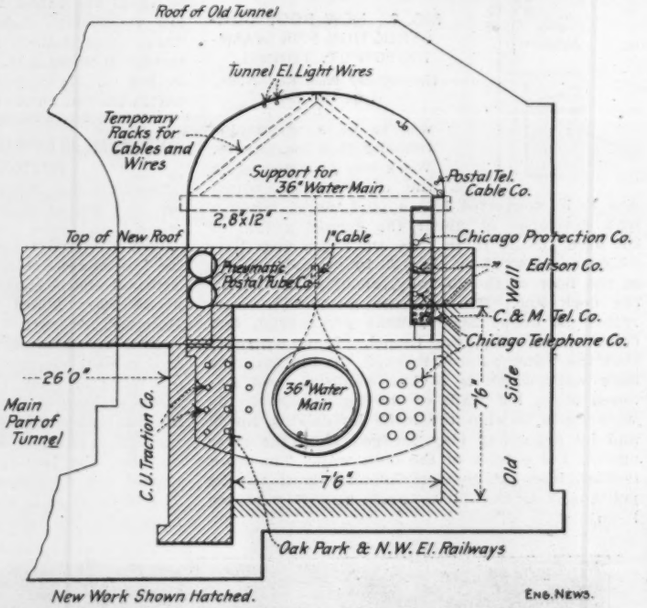


FIG. 5. SKETCH SHOWING THE NEW ROOF AND POSITION OF WIRES, CABLES AND MAINS IN THE FOOT PASSAGE, LA SALLE ST. TUNNEL, CHICAGO, ILL.

The average approximate length of the blocks is 4,000 ft., but it is intended to shorten the length where traffic is dense, while after the suburban districts have been passed the blocks will be lengthened. On single track, where arrangement must be made for rear and forward blocking, the signals will be staggered and overlapped a sufficient distance in order that ample stopping distance will be provided for all trains. At complicated yards, the automatic blocks will cease at the home signal or rear-home signal of the yard, and be picked up again at the advance signal of the yard, as it is considered that the leverman in an interlocking tower in congested yards can handle the traffic consisting of a large number of switching movements to better advantage if not handicapped by the semi-automatic signals.

An important point for consideration is the density of the traffic, or the average number of trains per day, and the minimum intervals between trains during busy hours on the signaled sections of the road. This railway is divided into a number of divisions, which are concentrated at Boston, there being 311 regular [illegible] inbound and outbound passenger trains [illegible] a total of 622 regular passenger trains [illegible] at the Boston terminal each day. Th[illegible] addition to a large number of freigh[illegible] which of course stop at the outskirts [illegible] diverted to the freight yards. Inbound [illegible] the morning and outbound trains in the [illegible] on each division during the busy hours a[illegible] uled from two to four minutes apart. [illegible] nals are located at such distances as [illegible] oughly protect traffic and yet not del[illegible] trains during such busy times. In the su[illegible] districts, where stations are close to each [illegible] the signals are where possible arranged [illegible] when one train has entirely cleared a [illegible] after leaving passengers, the following tra[illegible] receive a "clear" or "proceed" signal to en[illegible] station and leave its passengers, while [illegible] same time it will have protection behind i[illegible] following trains, should some of the [illegible] trains be delayed from any cause and [illegible] trains off their regular schedule. It is pr[illegible] to push the work of installation as rapidl[illegible] can consistently be done, all things consi[illegible] and it is expected that by next winter the l[illegible] part (if not the whole) of the double-track [illegible] will be completed.

Some extracts from the railway company's specifications for signals are given below:

GENERAL SPECIFICATIONS FOR ELECTRIC SIGNAL MATERIAL.

Boston & Maine Ry. (Signal Department).

SIGNALS.—The signals to be supported on a hollow iron mast at least 5 ins. internal diameter for its entire length. The signal mast to rest upon and be supported by a combined mechanism and battery case, measuring at least 6 ft. from top of foundation to bottom of cast-iron base of signal mast. The signal mast base to be slotted where fastened to mechanism case to allow of at least 2 ins. rotation of same, so as to allow of adjusting the position of face of blades in relation to curves. The signal mast to be fastened to the mechanism case by four ¾-in. bolts. The joint between signal mast base and mechanism case to be so constructed as to be water-tight without the use of cement.

The mast for a one-arm signal to be of such length as to bring the center of blade at least 24 ft. above top of foundation. The mast for a two-arm signal to be of such length as to bring the center of the lower blade at least 24 ft., and center of upper blade 30 ft. above top of foundation.

Wooden signal blades to be 4 ft. long with a width of 9½ ins. at the outer end and 7⅝ ins. at the inner end. They are to be made of clear second growth ash lumber. Blades to be ¾-in. thick at inner end tapering to ½-in. thick at the outer end; at 10 ins. from the outer end will be a cleat made of ⅝-in. half-round iron fastened to the back side of the blade with four $^{5}/_{16}$-in. flat head rivets.

Blade grips to be of the three-light pattern, arranged to support roundels 8⅜-ins. diameter, $^{9}/_{16}$-in. thick. The roundels to be held in iron rings bolted to the blade grip. The blade grip to be so designed that the center of upper hole will be in a line with center of signal blade when the blade is in a horizontal position. The blade grip and mechanism to be so designed and constructed as to cause a movement of the signal blade through an arc of 70°. A back light casting with opening to carry a 3-in. roundel will be furnished with each signal blade and operated by the same shaft. Clutches or latches arranged to prevent the signal blade being moved to the safety position from the outside shall be attached to each signal shaft.

The mechanism case to be of a suitable size to hold all the necessary controlling relays, lightning arresters and operating mechanism without crowding. The battery case to be of a suitable size to protect at least 16 cells of any make of caustic-soda battery on two adjustable shelves. Hinged doors on mechanism and battery cases to be provided with rubber tube gaskets and compression clamps, with suitable hasps for padlocks.

The battery case to have a 2-in. hole in the right-hand end, and 6 ins. below the top, to allow insertion of an iron pipe 1¼ ins. internal diameter to carry wires from underground to battery case. One piece of such pipe with one end turned at a radius of 7 ins., threaded for 1½ ins. and provided with two lock nuts, will be provided with each signal, and will be of sufficient length to extend 1 ft. below the base of the battery case, to prevent injury to wires running through the same.

For each signal there will be four 1-in. anchor bolts, 30 ins. long, with the end turned up at right angles for 2 ins.

Signal mechanism to be of the latest improved electrical motor pattern, so arranged that there will be no movement of the motor when the signal changes from the safety to the danger position. The connection from the operating mechanism and the up-and-down rod to be made by means of a clutch, slot arm or other satisfactory practical device. The interior arrangement of circuits to be such that the same battery operating the motor will operate and control the magnets of the slot arm or clutch. The upper signal-blade operating device will control the circuit of the lower blade operating device in such a manner that the lower blade cannot be cleared unless the upper blade is in the safety position, and the setting of the upper blade at danger will cause the lower blade to be set to the danger or caution position. Where it is desired to operate the blades as routing signals, however, the blades will be operated independently of each other. Pole changers operated by the clutch or slot arm of the upper signal to be furnished with each signal.

Where there are two signal blades on each post the slot or clutch magnet for the upper blade to be [illegible] 500 ohms resistance, and that for the lower blade to be of 2,000 ohms resistance. Where single-bladed signals are furnished, the resistance of the slot or clutch magnets will be 2,000 ohms or more. The slot or clutch magnets

of ... blades must have a retardation of 0.8 second, ... if found necessary.

... operating motors are to be provided with glass ... over the commutators, to prevent accumulations ... on the commutators and brushes. The motors ... mechanism should be so designed as to re... current of not more than 2 amperes at nine ... 2.25 amperes at 5.5 volts, during the time re... to operate the blade grip with roundels in and ... the blades being attached; operating the castings ... of nine seconds in the first case, or inside of 13 ... at the lower voltage.

RELAYS.—The relays to be made in accordance with ... best practice, in a strictly first-class manner, and ... from residual magnetism or other defects which ... their efficiency. Magnets of all relays to be ... when in working position. No tension springs ... required or used.

... armature of a 5-ohm relay must be adjusted to ... at 70 mil-amperes, and to break contact when ... is reduced to 30 mil-amperes, after having the ... current increased to 110 mil-amperes, before re... The armature of a 9-ohm relay must be ad... to pick up at 45 mil-amperes and to break ... when current is reduced to 20 mil-amperes, after ... the initial current increased to 80 mil-amperes.

Neutral relays to be provided with two front and two back contacts. The former to be of platinum to carbon, and the latter of platinum to platinum. Carbon must not be silver or metal plated on contact surfaces. Polarized or differential relays in addition to the above contacts to be provided with two front and two back contacts constructed as above. All contacts to have a sliding motion. One side of each contact to consist of two or more finger-shaped pieces, each finger to be at least ⅛-in. wide.

The insulation of the magnet winding from the core of the contact springs and parts carrying current from the armature, and of parts of one circuit from another, must be such as to withstand a test with an alternating current of 3,000 volts without the insulation breaking down or a short circuit forming.

All moving parts, contacts, etc., to be protected by glass covering to exclude dust or any foreign matter. Methods of sealing this cover must be provided to prevent adjusting or tampering with the relay without breaking the seal.

BATTERY CHUTES.—The battery chutes to be of cast-iron 7 ft. long, with an internal diameter of not less than 9 ins. for 6 ft. of their length. The balance of the length to have an internal diameter of at least 10 ins. Wall of chute to be at least ½-in. thick.

One elevator, to hold three cells of 6 × 8-in. battery, to be furnished with each chute. The elevator to be provided with 7 ft. of manila rope, with an eye at one end, spliced to the lifting eye of the elevator; the free end to pass through hole in frost board of chute.

SWITCH BOXES.—These are to be of cast iron, and so arranged as to provide two make and two break contacts at each operation of the switch, and capable of an adjustment to operate on a movement of the switch of not more than ⅝-in. Lugs to attach to switch points and connecting rods with screw jaws, together with all bolts and lag screws, to be furnished with each switch box.

REPORT OF BOARD OF RAILROAD COMMISSIONERS OF NEW YORK ON DRAWBRIDGE PROTECTION.

The Board of Railroad Commissioners of the State of New York have recently completed an examination of all the drawbridges on railways under their jurisdiction with a view toward recommending certain changes in the equipment of such bridges which would tend toward a greater safety to the trains passing over them.

The report of the expert delegated to inspect the drawbridges and recommend the above-mentioned changes, is in part as follows:

There are in this State 41 openings in the main track roadway of steam railroads, for passage of boats. At most of such openings there are swing bridges; a few are lift bridges, and there is one, in the Rutland Railroad, where the Addison branch crosses Lake Champlain, where a float draw is used.

The method of operating, protecing draw, connecting shore and bridge rails, etc., differs greatly on different roads, and in many instances on the same roads. I find none where the conditions, as operated, can be considered dangerous, and at only a few, where the protection is especially good, do the trains run at speed when crossing the draws; at all others the trains are required to come to a full stop before crossing or run with train under perfect control.

The method of securing the movable rails, that are necessarily unspiked for much of their length, at the ends of most drawbridges, the manner of signaling the approach to the draws, and the interlocking of the signals with the mechanism operating the draws can in nearly all cases be improved. I also consider that there should be derailing switches in all tracks approaching the draws, located a sufficient distance from the end of the bridge that a train derailed thereby would not be likely to run far enough, on the ties, to get into the draw opening; guide rails can be secured to the ties that will prevent a train so derailed getting away from the track.

I respectfully recommend the following method of securing movable rails on drawbridges and signaling and protecting operation of trains crossing them:

The movable rails on ends of all drawbridges to extend two feet or more beyond the end of the bridge, and together with the shore rails, to have a miter joint; rails cut at an angle of approximately 30°; points to be trailing for double track bridges and to be trailing for those approaching the draw on single track bridges; the mitered rails to meet in a "trough" or channel not less than three feet in length, that will insure the rails being held in correct alinement; the movable rails to be bolt locked in position and the bolt lock to be interlocked with the signals governing the approach to the draw; the movable rails to be not less than 17 ft. in length and for at least 12 ft. of their length, on the bridge, to rest when in place on plates that shall have an angle, or raised plate on the outer side that will prevent the rails being moved outward. This plate may be in sections, with space of one tie distance between the sections. These plates to be firmly secured to the bridge ties and the rails to be connected to each other by at least four tie-bars.

The draw must be protected by home and distant signals and also by derails, the derails to be located, wherever practicable, not less than 500 ft. from the end of the draw, the home signals about 50 ft. farther away, and the distant signals not less than 1,500 ft. beyond the home signals, and all interlocked with the mechanism of the draw in such manner that the first movement toward opening the draw sets the distant signal to the danger position, next, the home signal to the danger position, then opens the derail; then the bolt lock securing the movable rails may be withdrawn, the rails raised, draw unlocked, wedges withdrawn and draw opened. The locking to be in such manner that when the draw is again closed, the wedges inserted and draw locked, movable rails lowered to place and bolt locked down, then derails can be closed, home signal cleared and the distant signal cleared; and that the above described movements can only be done consecutively and in the order named. In cases where the draw lifts, the rails on the end of the bridge can be securely spiked to the ties and will raise and lower with the bridge, but the method of connecting them at the ends of the draw will be the same, as will be the method of operating the bridge, bridge lock, rail lock, derails and signals.

If it is desired to use square end instead of mitered rails, with all the balance of protecting, etc., as above described, the only difference will be that the open joint will not ride quite so pleasantly, but will be practically as safe, and I see no serious objection to that form of joint being used. In some cases where the block signal system is in use and block towers are near the drawbridges, the draws are interlocked with the towers in such manner that the bridge tenders cannot make any movement towards opening the draws until unlocked by the signal tender. This is a good plan and should be followed wherever it can be done consistently.

A copy of the above report was sent to each of the railroads operating drawbridges in New York as the recommendations of the Board of Railroad Commissioners to the railway.

A LEVELING INSTRUMENT FOR BUILDERS AND FARMERS.

There is a large field of usefulness for a leveling instrument intermediate in accuracy and price between the hand-level and the conventional types of surveyor's level. The gap between the price of a Locke hand-level and the cheapest tripod levels is surprisingly large, fully as large in fact as the difference in the grades of accuracy attainable with the two instruments. Not long ago we described a new form of level brought out in part to fill the gap: a 10-in. hand-level which, besides having stadia wires in the reticule, is adapted for mounting on a Jacob-staff and is fitted with slow-motion leveling attachment in addition to a quick-leveling head. A different style of cheap leveling instrument is being made by the Bostrom-Brady Mfg. Co., of Atlanta, Ga. This instrument is mounted on a tripod, has four leveling screws, and carries a graduation to degrees on its horizontal plate. It is intended for short-distance work of low precision, like that required by builders in setting foundations for buildings and machinery, etc., or by farmers in running drains and the like. A special aim in its design was to produce a simple and rugged device, whose use and adjustments could be easily understood by workmen, and which would not require highly careful handling.

Fig. 1. Bostrom Builders' Level, on Tripod.

A few words of explanation in connection with the two illustrations herewith will make its construction clear. Fig. 1, reproduced from a photograph, gives a general view of the instrument, and Fig. 2 shows a vertical section through center line of telescope. From Fig. 1 it will be seen that the sighting telescope is carried in a round box-shaped frame, the turret. This is faced on top and bottom, and rests in a recessed seat on the main plate. The turret also contains the level bubble-tube. The main plate is carried by three leveling screws bearing on a base-plate screwed to the tripod-head or foundation-casting. The turret is free to turn in its seat in the main plate, but can be removed from its seat only on releasing a spring catch which holds it loosely in place.

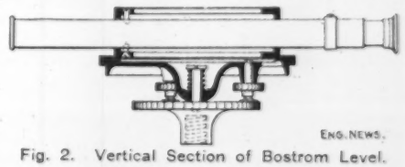


Fig. 2. Vertical Section of Bostrom Level.

The turret, as Fig. 2 shows, is a ring-shaped casting stiffened by annular webs at top and bottom. The catches by which it is held down on its seat are not shown; they are three pivoted latches fastened to the main-plate, which lap over the lower flange of the turret under the pressure of a spring, and are simultaneously drawn back when a button on the under side of the plate is pressed back. The main-plate is held to the base-plate by a spring bolt, as required in all instruments of three leveling screws. The telescope has a magnification of about eight diameters. The cross-hairs are fixed, and the adjustment of line of sight is made by lowering or raising the front end of the telescope tube by the vertically opposed adjusting screws shown in Fig. 2. The bubble-tube, which is alongside the telescope, is held in the turret in the same manner, with adjusting screws at its forward end. The bubble is claimed to have a motion of 0.1-in. for a rod reading of 0.1-in. at 100 ft. distance, which would correspond to a sensitiveness of about 18 sec. per 0.1-in.

The two adjustments of the instrument: setting the level bubble parallel to the faced surfaces of the turret, and setting the line of sight parallel to both, are made in simple and obvious manner, the second adjustment being accomplished by turning the turret upside down just as in determining the parallelism of a plate or block by means of a spirit-level. The adjustment assumes, of course, the parallelism of the upper and lower face of the turret. To test the latter, recourse would have to be taken to the conventional peg-method.

The instrument is made in two styles. In the Builders' Level all parts are of brass, and the main plate has a degree graduation outside of the turret ring, which in conjunction with an index mark on the turret makes it possible to get a rough reading of horizontal angles. This instrument is sold for $25; for $7.50 additional a compass is supplied, to be set on top of the turret, for running lines by magnetic bearings. In the Farmers' Level, all parts except the telescope and bubble-tube are made of iron, these two parts being of brass. It sells for $12.50. A target level-rod is furnished with each level.

A STEAM OMNIBUS FOR SERVICE IN LONDON STREETS.

As many of our readers are aware, the trolley car, which has become the universal street conveyance of American cities, large and small, is still far from universal in Great Britain. London passenger traffic, notwithstanding all the progress made in the construction of underground tube railways and the building of municipal electric railways by the London County Council, is still largely carried in horse-drawn omnibuses.

Within a year or two past, the introduction of motor omnibuses in place of the horse-drawn vehicles, has made rapid progress, and we believe between one and two hundred such vehicles are now in service.

A considerable proportion of these omnibuses are steam machines, although in England generally, steam automobiles are less common than in the United States. At a recent meeting of the Institution of Mechanical Engineers, Mr. Thos. Clarkson, of Chelmsford, England, who has been prominent as an engineer and manufacturer in the development of motor vehicles, described a steam driven omnibus of his design. The paper is of particular interest at this time for comparison with Prof. Carpenter's paper, read before the American Society of Mechanical Engineers, and also published in this issue, on the White steam motor car. The following is an abstract of Mr. Clarkson's paper:

The advantages of the steam omnibus over omnibuses propelled by internal combustion engines may be summarized as follows:

The employment of a safe and cheap fuel; freedom from noise and vibration; absence of smell; smooth and silent action of the machinery; quick acceleration without jerkiness; flexibility of drive and simplicity of control; large reserve power for hills and for overcoming the inertia of starting; absence of change-speed gears; absence of electric ignition, and absence of friction-clutch.

To realize these important advantages a very perfect steam-generator is necessary. The usual methods for the generation of steam are characterized by smoke, dirt, sparks, ashes, almost constant attention to the water-feed and to stoking, trouble from priming, from incrustation, and from leakage. It is surprising to many engineers to find that steam can be generated automatically as required, without any of these drawbacks, and that the generator, instead of being a delicate thing needing careful handling and attention, has been made robust and healthy, and, for all practical purposes, "fool-proof." For the purpose of description, the generator, shown complete in Fig. 1, may be conveniently divided into three parts, namely: the burner, the boiler, and the governing gear.

THE BURNER AND OIL SUPPLY.—The burner is constructed upon the principle of supplying liquid fuel (paraffin) under a constant pressure to a vaporizer, in which it is transformed from the liquid to the gaseous state. The oil vapor is then mixed with air—on the Bunsen principle—before ignition takes place, and the heat generated by the combustion maintains the temperature of the vaporizer, chiefly by radiant effect.

The main fuel-supply is carried in a tank which is not subjected to pressure. It can therefore be replenished quickly at any time without extinguishing the burner. The paraffin is pumped from the main tank into a pressure tank of solid-drawn steel, which is about half full of air. This forms a cushion which equalizes the flow, and keeps the burner fed when the car is standing and the pump not delivering oil. The surplus oil delivered by the pump escapes through a spring-loaded relief-valve set to about 40 lbs. pressure per sq. in., and returns thence to the main tank. To prevent loss of pressure by leakage through the relief-valve when standing, a lock-up valve is provided, which, when closed and the burner out of use, will retain the pressure for long periods ready for the next lighting up. The air-cushion in the pressure-tank gradually diminishes with use, by "foaming" or absorption into the oil. It is replenished by a few strokes of a hand-pump before starting each morning.

The oil-supply to the burner is connected to the lower end of the vaporizer, from the upper end of which the vapor is conveyed to the jet-nozzle. The area of the jet nozzle is regulated by a wedge-shaped needle. This needle performs a dual function in assisting to keep the nozzle clear of obstruction, in addition to controlling the supply of vapor to the burner, and thus determining the size of the flame and the rate of combustion. The rate of combustion is not governed on the oil-supply, but on the supply of oil-vapor. This is found to be more convenient in securing a proportionate admixture of air with the vapor for complete combustion at all rates of consumption, from the minimum to the maximum, and at all intermediate rates of consumption. The jet of vapor is directed along the axis of an inducing or mixing tube. One end of this tube is open to the atmosphere when running, and the other delivers the mixture of vapor and air into the center or body of the burner, in which a small pressure is maintained by the force of the vapor-jet. This in turn is derived from the pressure of oil in the supply tank. It follows that this pressure must be maintained practically constant to ensure regular results in the working of the burner. The mixture of vapor and air is permitted to escape from the body of the burner through a series of circumferential slots or ports, similar to the openings in a piston-valve liner. The degree of opening of the ports is controlled by a piston-valve moving freely inside the body, the valve being carried upon a central stem.

The port area varies in arithmetical ratio, and the addition of each $^1/_{32}$d to the stroke of the valve increases the area of the opening by an equal amount. It is necessary also to ensure, for the correct working of the burner, that the supply of vapor to the inducing tube shall also be varied in a corresponding ratio. To obtain a supply of vapor in arithmetical ratio it is necessary to form the jet-nozzle either square or rectangular in shape, and to control the opening by a wedge-shaped needle having parallel sides which fit accurately into the nozzle. It will thus be noted that, as the wedge is introduced or withdrawn from the orifice, the area is diminished or increased in one dimension instead of in two, as would be the case with a circular orifice. This method of varying the area, for the escape of the fuel mixture in strict accordance and simultaneously with the supply of vapor to the burner, overcame the serious difficulty of "back-firing" or "lighting back." The simple explanation is that the velocity of efflux of the vapor mixture is maintained always in excess of the velocity of the propagation of flame. Hence the flame is kept outside of the burner body.

The subdivision of the mixture, obtained by delivering it through the ports, facilitates the access of air to the flame by providing a number of air-passages. The method of breaking up the flame possesses the important advantage of reducing the noise. Originally, six ports were used. Better results are now obtained by employing thirty. The flame, which is in the form of a basin, is received and steadied by a conical frustrum which becomes incandescent. This shelters the flame from irregularities in the air supply, and its radiant heat is focussed upon the vaporizer, which is located within the hollow of the flame.

In starting the burner, all that is necessary is to heat the vaporizer to the working temperature, to turn on the oil-supply and apply a light to the mixture of vapor and air as soon as it appears. The preliminary heating can now be done in one minute by the employment of paraffin, and the heat is obtained in the following manner: A cast-iron box, called the starter-box, contains several asbestos wicks which are saturated with paraffin, and which readily ignite from a match. A current of air is blown from a fan into one side of the box. Through the other side of the box a strong flame is driven, which is directed through a tube surrounding the straight part of the vaporizer. The end of the flame is directed against the body of the burner, and in close proximity to the ports, so as to promptly ignite the vapor mixture as soon as it comes through. This arrangement will start the main burner in 50 seconds, and the omnibus can move by its own steam in ten minutes from "all cold."

THE BOILER.—The boiler is constructed [illegible] of water-tubes. These are disposed so as to a[illegible] the maximum heat from the products of combusti[illegible] fore the latter are allowed to escape, by employin[illegible] re-generative principle. That is, the general di[illegible] of the water through the boiler is opposite to th[illegible] the hot gases. The tubes nearest the fire are m[illegible] ned at a fairly constant temperature by the emplo[illegible] of a thermostat, and the regulation of the wate[illegible] is governed directly by the pressure of steam g[illegible] ed. A water-gage is unnecessary, and joints are not [illegible] sed to the hot gases.

There are thirteen elements or conical coils of t[illegible] in-volute in plan, and enclosed by a cylindrical casi[illegible] The alternate coils are moved round half a revolution [illegible] as-sembling; this has the effect of staggering the [illegible] rals and so breaking up the gases during their passag[illegible] long the tubes. The coils are bolted to a conical steel frame which rests upon the main frame. Beneath the main frame is secured a cylindrical fire-box, the upper part of which is lined with a coil of close wound tube. This forms a water-lagging to the fire-box, and, besides preserving it from injury, has the incidental advant[illegible] of warming the feed-water before it enters the gen[illegible]tor. From the upper end of the feed-coil the water is transferred to the topmost coil of the generator, through which it circulates from the outer edge, rising towards the apex of the cone. The water then passes to the outer edge of the coil immediately below, and so on to the one nearest the fire, with the exception that it passes by or skips over the fourth coil from the bottom.

The conical formation of the coils is a very important matter in providing effective means for retaining the contents of the generator in place. Thus, in the upper part of the generator the tubes are filled with water, but as the water descends and commences to evaporate, the tubes become charged with a mixture of steam and water, in which gradually the steam predominates. In the lowest coil there is practically no water. This is the natural arrangement of the contents of the generator when running. On closing the throttle and stopping the circulation through the generator, the steam in the lower coils would naturally rise into the upper, thus allowing the water to descend and come in contact with the hotter tubes, in this way making more steam at a time when it was not required. The conical shape of the coil prevents this by providing a trap or lock, which the author has named a "steam-ratchet." The steam in each conical element can only rise into the center part or apex, and the water gravitates to the outer edge. There they remain until circulation recommences on the opening of the throttle. From the apex of the lowest coil the steam passes through a thermo-governor, and thence into the fourth coil from the bottom, which forms a reserve immediately behind the throttle-valve.

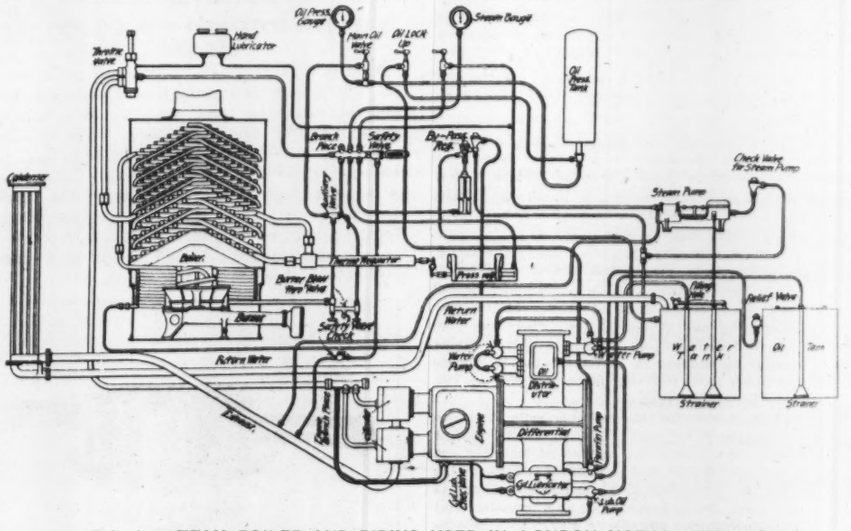


FIG. 1. STEAM BOILER AND PIPING USED IN LONDON MOTOR OMNIBUS.

The products of combustion are allowed to escape either by a chimney (up draught) in the case of single-deck omnibuses, or by lateral openings (side draught), in the case of double-deck omnibuses.

THE GOVERNING GEAR.—The full power of the burner is in excess of the maximum demands for heat, and the fierceness of the flame is continually kept in check by the governor, in a manner analogous to the action of a steam-engine governor, which regulates the supply of steam in accordance with the variations of the load. The governing gear may be divided into fire-control and water-control.

The main principle governing the fire-control is the maintenance of an equable temperature in the steam which is generated; in other words, the supply of heat

to the generator is governed by the temperature of the steam generated. The steam is delivered from the generator in a superheated state, and from 700° F. to 800° F. is found to be a convenient temperature. The employment of highly superheated steam is essential for economical working.

In order to employ the temperature of steam as a governing factor, the most effective control of the fire is secured by the combined action of temperature and pressure. The temperature is the main factor when running, and the pressure when standing. The employment of pressure is really a conversion of thermal

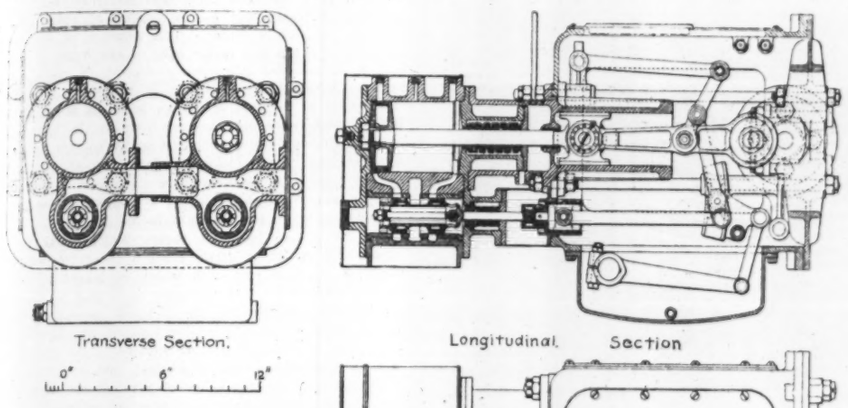


FIG. 2. ENGINE FOR LONDON STEAM MOTOR OMNIBUS.

effect to meet the special circumstances of the case, and, speaking broadly, the control of the fire is due to the temperature of the generator and its contents.

The water-control of the generator is in the form of a by-pass regulated by the steam pressure. The pumps are always taking the full charge of water, which is either delivered into the generator, or allowed to return to the tank should the by-pass be open. There is no intermediate condition. When the pumps are not delivering into the generator, they are absorbing practically none of the engine-power, as the water is merely circulating through an unrestricted passage in which the friction is very small.

The evaporative efficiency of this generator was tested in the following manner, and the results are indicated below. The burner was adjusted to consume 50 lbs. of oil per hour at a uniform rate. Over the burner were placed successively 1, 2, 3, 5, 7, 9 and 12 elements. Water was fed downward through the elements at a rate sufficient to maintain a pressure of 300 lbs. per sq. in. The throttle opening was adjusted to maintain the temperature (of superheat) at 800° F.

Number of coils.	Lbs. per hour. Fuel consumed.	Water evaporated.
1	50	110
2	"	190
3	"	255
5	"	360
7	"	405
9	"	455
12	"	520

THE ENGINE.—The engine, Fig. 2, has two horizontal double-acting cylinders 4 ins. diameter by 4 ins. stroke, which are in two separate castings, with a view to prevent distortion by the employment of highly superheated steam. The cylinders are attached to distance-pieces bolted to the outside of the aluminum gear-box, which contains the crank-shaft, crossheads, connecting rod, and all the valve motion. It is found convenient to place the valves for the distribution of the steam beneath the cylinders, as this dispenses with the necessity for the employment of drain-cocks for removing the water of condensation at starting. The water readily gets away through the exhaust immediately the port is opened, and the employment of drain-cocks has been found unsatisfactory in the hands of the ordinary driver; for he generally either omits to open them or leaves them open, and they then give trouble through leakage. The elimination of the drain-cocks is therefore an important advantage.

The valves are of the piston type fitted with rings, and are actuated by Joy gear. This enables a very simple form of crank-shaft to be employed, which is built up of two parts, each forged out of the solid, and bolted together with a steel spur-wheel in the center. The cranks are at right angles and the crank-shaft is hardened and ground on both the journal and the crank-pins. No adjustment is provided in the engine motion, but the principle is adopted of giving very large and well fitted surfaces of the hardest bronze, working against a hardened and ground steel face, and with a constant flow of oil over them. In this way the wear is reduced to a minimum, the time of making adjustments is saved, and the risk of bungling over adjustments and the consequent excessive friction and wear are obviated. Such an engine will run 30,000 miles without getting any appreciable knock, and when the knock develops, it is arranged to readily fit new bronze bushes into the motion.

In 1905, the first double-deck steam omnibus of the author's construction commenced regular service in London, and at present there are about forty licensed by the police for service in London. About one hundred of these vehicles have already been made.

In presenting this paper before the Society, Mr. Clarkson made some additions to the text. Referring to the advantages of steam over other kinds of motive power for street vehicles, he said that some claimed steam omnibuses to be more expensive in fuel consumption than gasoline machines. If the limit of economical work had been reached in steam and the price of petroleum would not rise above its present figure, he admitted there might be something in this assertion; but, as the economy of the steam machine was steadily improving, and there was also a tendency to increase the price of petroleum, these influences would combine to place the steamer well ahead in respect of fuel cost, as it already was in cost of maintenance.

Colonel R. E. B. Crompton opened the discussion of this paper, referring to Mr. Clarkson, in England, Mr. Serpollet, in France, and Mr. White, in the United States, as being chiefly responsible for the advance made in rendering possible the use of steam for passenger traffic on roads. He did not believe one was justified in assuming that the ordinary methods of steam generation and application represent the highest practical possibilities. We have been using hot-water engines, said he, instead of steam engines up to now, and he felt convinced that if steam was to make any fight against the internal combustion engine, it must be by the development of superheated steam. This might mean revolutionizing the present method of constructing land and marine engines, but it would have to be done if steam is to compete with gasoline or oil engines.

Colonel Crompton gave to Mr. Serpollet the credit for the development of steam generators of the flash type. He said that the subject of the circulation in a flash boiler is only now being understood; in fact, it is a new science. While flash boilers are never troubled with incrustation, they sometimes have a habit of sulking; that is, losing temporarily the greater part of their power and then suddenly regaining it. Mr. Serpollet attributed this to a priming action; that little globules of water were shot through the tubes in a spheroidal state by the superheated steam. He prevented it by reversing the coils, thus reversing the motion of the steam in the generator.

Mushroom valves, according to Colonel Crompton, are the only type desirable for high temperature steam. He said there had been a revolution in the use of steam in Great Britain, and that link motions with slide valves are either dead or passing away. The cam with the lift-valve is taking its place, and by cutting off the steam at an early part of the stroke Mr. Serpollet had secured with a simple engine as good a result as others had obtained with ordinary compound and triple-expansion engines. Mr. Serpollet's practice, he remarked, differed from that of Mr. White, in that the latter adopted extreme expansion with a low-pressure cylinder four times the capacity of the high-pressure cylinder. Mr. White had, however, approached nearer the internal combustion engine in regard to actual efficiency of fuel than anyone else with whose records the speaker was familiar.

Mr. David J. Smith, the English representative of Mr. Serpollet, remarked on the scarcity of data relating to superheated steam. He did not think that Mr. Clarkson superheated quite enough. In the Serpollet generator steam was used at 1,200° F. Although it had been said that with this degree of superheat it was not possible to lubricate properly, there was no difficulty in this respect. By the time the steam was reduced to the pressure at which it worked in the cylinder it had dropped to 800° or 900° F., a temperature at which the steam in Mr. Clarkson's system left the boiler, and at which there was no difficulty in lubricating the cylinders.

According to Mr. Smith, Mr. Serpollet had started with a four-cylinder, single-acting engine, and had now a double-acting engine; he had retained mushroom valves, because he found it impossible to lubricate either slide or piston valves at the temperature at which he worked. Mr. Smith referred to a 5-HP. engine, using 10 lbs. of steam per horse-power hour—a consumption thought impossible except with large plants, either compound or triple-expansion.

Mr. Serpollet, continued the speaker, considered automatic devices troublesome, and he has therefore abandoned all such devices for regulating the burner or the pressure. Any undue pressure in the generator is relieved by a safety valve which blows water, not steam, out of the generator. The driver has any range of pressure between 200 lbs. and 1,200 lbs. at his disposal.

Mr. Smith said that the life of flash boilers is believed to be fairly long, but Mr. Serpollet did not claim that the duration of his boilers would be as long as that of Mr. Clarkson's generators, where the temperature of the steam was regulated by a thermostat; but in actual practice Serpollet boilers frequently worked for 18 months without the replacement of a coil.

Mr. Ernest W. Fuller, engineer of the Torquay Motor-Bus Co., Torquay, England, said the company he represented had eight of Mr. Clarkson's cars, and that one put in service three years ago had covered 48,000 miles with the same boiler and the same tubes in use.

Mr. W. J. Talbot, of Walsall, England, suggested that engines like those of Mr. Clarkson's manufacture might be greatly simplified and cheapened by the use of bushes in place of complicated mechanisms for the adjustment of wearing parts.

BRIDGES OVER NAVIGABLE STREAMS are affected by a decision of the United States Supreme Court of Feb. 25. The Secretary of War had ordered a bridge over the Allegheny River in Pittsburg, owned by a private company, to be raised, and the bridge company appealed from this order on the ground that the act took property without compensation. The court upholds the Secretary of War.

STEAM PLANT OF THE WHITE MOTOR CAR.*

By R. C. CARPENTER,† M. Am. Soc. M. E.

The steam plant of the White Motor Car is an example of what can be accomplished on a small scale in the use of steam of high pressure and with a high degree of superheat in the steam engine and is consequently of interest to the mechanical engineer irrespective of its special application for the propulsion of motor cars. A description of this plant and the results of a series of tests conducted on it will doubtless prove of considerable interest to all engineers who are studying the question of the use of steam at high temperatures and pressures.

The White steam system was designed by R. H. White and has been successfully applied by the White Sewing Machine Company during the last six years to several thousand motor cars; its essential and novel features are found principally in connection with the steam generator or boiler which is adapted to produce steam of high pressure and high temperature. The system is also of interest in the details of construction of its engine and in the means for automatically controlling the quantity, temperature, and pressure of the steam produced.

It is a well recognized fact that the efficiency of a steam plant is increased by the use of steam at high temperatures and pressures, and there are numerous tests on record which bear testimony to this fact. The development of the art of producing and using steam of high pressure and of high superheat has been slow although probably continuous. So far as the writer can learn from correspondence, no boilers or engines exceeding 100 HP. in capacity which are adapted to produce and use steam exceeding 300 lbs. pressure and 300° superheat are built in this country at the present time. At least he has been unable to find makers of both boilers and engines who could meet that kind of a demand.

The practical limit of pressure in steam plants of any considerable size in this country at the present time, taking into account boilers, engines, piping and valves, is not much above 200 lbs. per sq. in. There are but few engines adapted for using steam with a superheat of 200° F. This condition is doubtless accounted for by the existence of numerous practical difficulties, many of which relate to piping and valves and to the materials of construction which are now in ordinary use. There are also, no doubt, commercial difficulties of importance connected with the cost of manufacture and with the demand. The writer believes, however, that if the steam engine is to maintain its position as the principal power producing machine in competition with the internal combustion engine, the steam pressure and degree of superheat must be very largely increased over that in use at the present time. To meet these conditions there will be required many changes in design and construction of both engine and boiler which will probably require a long period of development to perfect.

The steam turbine which is already in extensive and successful use is well adapted for steam of high pressure and a high degree of superheat, without change of design or construction, and will doubtless be used in a continually increasing proportion for producing power as the art of producing steam of high pressure and a high degree of superheat is developed.

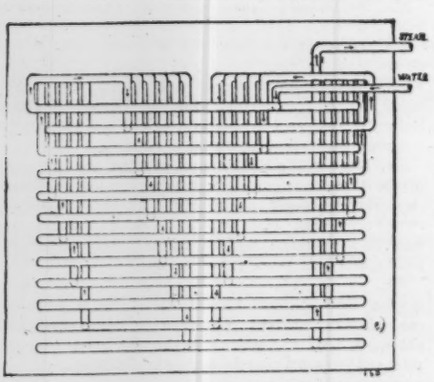


Fig. 2. Diagram of Generator Circulation.

*Extract of a paper presented at the New York meeting (December, 1906), of the American Society of Mechanical Engineers.

†Professor of Experimental Engineering, Sibley College, Cornell University.

THE BOILER.

The steam generator or boiler of the White system is a series of horizontal coils connected so as to form a continuous tube through which all the water fed to the boiler and all the steam discharged from the boiler must pass. It is not provided with any reservoir either for water or steam. A perspective view of the boiler as used in the 1906 car is shown in Fig. 1 with the external casing removed. Its essential distinctive feature from every other boiler is due to the fact that the water is kept at the top and the steam at the bottom; it differs from all types of stationary boilers by the absence of a reservoir for steam. The construction of the boiler for the 18-B. HP. engine which was used in the 1906 cars is essentially as follows, and is typical of all sizes: eleven helical coils of drawn steel tubing are joined in series and connected as shown in the diagram, Fig. 2, so as to produce a system of circulation of such a character that the water or steam, in order to pass from one coil to that next below, must rise to a level above the top coil before it can pass down again. Fig. 1 shows the external view of the connections referred to, which pass from the external circumference of the coil upward to a point above the level of the top coil and thence downward in the central space, where it joins the coil of a lower level. Tubing having a nominal internal diameter of ⅝-in. was used in the boilers of 1904, 1905 and 1906, and of ½-in. in the new boiler recently built for the 1907 car. The joints connecting the various coils are, it is noted, located in an accessible position. This construction makes it possible to maintain water in the upper portion of the boiler and steam in the lower. It prevents the water from descending by gravity and renders the circulation through the generator dependent upon the action of the pumps which supply the boiler with water. The general direction of circulation of the water and steam is the reverse of that of the products of combustion.

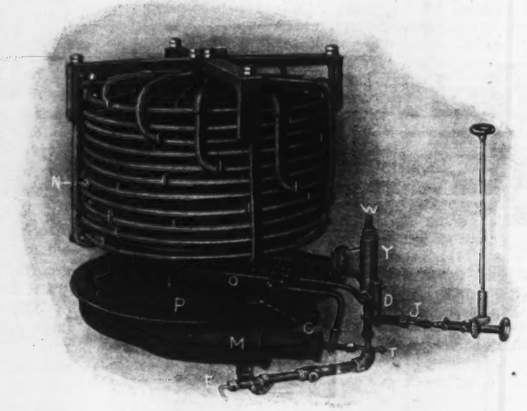


FIG. 1. THE STEAM GENERATOR IN THE WHITE MOTOR CAR, SHOWING ALSO THE BURNER, VAPORIZER, PILOT LIGHT AND GASOLENE CONNECTIONS, WITH EXTERNAL CASING REMOVED.

The White boiler has frequently been classified as a flash or semi-flash boiler; whether this classification is correct or not depends upon the definition of the term "flash boiler." In the flash boiler, as the writer understands the term, water is suddenly converted into steam by contact with a very hot metal surface and in the operation of such a boiler the metallic surface with which the steam is brought in contact is maintained at a much higher temperature than that of the steam. The White boiler, as noted from the description, always contains a considerable amount of water which is forced downward and over the heating surfaces at a rate proportional to the demand for steam, and under its normal mode of operation it is doubtful if the metallic surfaces have much or any higher temperature than that of the steam which they contain. The name Continuous Flow or Singe-Tube Boiler would, it seems, better describe the class to which the White boiler belongs than the term "flash."

STRENGTH.—Each pressure element is small in diameter, and consequently of great strength and not likely to be strained to any high percentage of its ultimate strength by any pressure which could be produced under ordinary conditions.* The high working pressure gives great power to the engine and explains the great success of the car in climbing high hills and in passing over unusually bad roads. A safety valve, not shown in the drawing, is attached which may be set at any desired pressure but is usually set to blow off at from 1,000 to 1,200 lbs. per sq. in. Because of the small quantity of water and steam present in the boiler no serious damage is able to person or property, even should the boiler be accidentally split or ruptured, as the effect would be simply that of allowing the steam to gradually escape without producing any disastrous results, and such accident has been extremely rare. Considering the fact that thousands of these steam generators are in the charge of men who have had practically no experience in the operation of steam plants, the results as to freedom from accident are remarkable, and indicate that the apparatus is, from the standpoint of safety, not open to criticism.

*The strength of the fittings at the point of leakage for the tubing was found to vary from 7,000 to 18,000 lbs. per sq. in.

Investigation indicates that there has been very little practical difficulty due to the deposit of scale in the tube of the White boiler. The velocity of discharge of steam through the single tube of the boiler is great and it is believed has been sufficient to remove the deposits in nearly every case. In the boiler, of which the results of the test are given later, as much as 188 lbs. of steam were produced per hour by the ½-in. tube. Without taking into account the extra volume produced by superheat, the calculated velocity approximates 600 ft. per second through the tube. Because of increased volume due to the high degree of superheat the actual velocity approximates one-third more.

For the actual operation of the White boiler on the motor car, water is taken from a reservoir which is supplied in great part with water condensed in an air surface condenser. The condenser is located at the front of the car and receives the exhaust from the engine which contains an appreciable amount of cylinder oil. A large proportion of this oil remains in the water tank and is discharged when convenient, but at times quite a considerable amount is forced through the boiler. So far as the makers have been able to ascertain, no injurious effects have been caused by this practice and as a consequence they have made no attempts to introduce a separator for removing this oil.

THE BURNER AND FUEL CONTROL.—The furnace or burner which is employed with the steam generator for use on the motor car is shown at P, Fig. 1, located beneath the boiler and adapted for the burning of gasoline vapor. The figure also shows the various means of automatic control of fuel and water which are employed with the generator. While burners of other types adapted for other fuels than gasoline can and doubtless will be used when conditions demand it, the gasoline burner employed has proved very efficient. In the burning of gasoline a vapor must first be produced by heat or other means which must be mixed with air previous to the combustion in order to give perfect results and high efficiency; for this reason all gasoline burners are provided with means of vaporizing the gasoline before it is fed to the furnace, which usually consists of means for heating termed a vaporizer, as is shown at O, Fig. 1. The burner consists of a cast-iron grate with slotted openings shown at P with a sheet metal chamber underneath closed except where pipes enter for admission of air as shown at M. In the 1905 car, the air pipes were directed radially into the chamber below the burner. In the 1906 car the air pipes direct the entering air tangentially, as shown in Fig. 1. The change in the direction of the air pipes has resulted in a decided reduction of noise and an increase of capacity and efficiency of the burner. For the 1907 car the air pipe is supplied with a regulating valve. The gasoline is supplied through a pipe and flows past a valve D which is operated by a thermostat; it then flows into the vaporizer O, where it is heated; thence it flows to the center of the air pipe M.

The thermostat shown at Y in Fig. 1, and in detail in Fig. 3, consists of a rod inserted into the steam pipe so as to be in contact with the steam on its passage from the boiler to the engine. The expansion of this

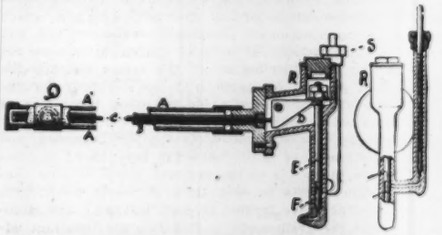


Fig. 3. Thermostat for Controlling the Gasolene Supply.

rod controls the gasoline valve at D, Fig. 1, and at F, Fig. 3. The thermostat is ordinarily adjusted so that the oil supply valve will remain open until the temperature of the steam rises to about 800° F. In order to light and relight the main burner when necessary, a small gasoline flame called a pilot flame, shown at C, Fig. 1, is kept burning constantly during the time the vehicle is in use. The valves for the hand control of the gasoline supply are shown at L, Fig. 1. In the operation of the burner the gasoline is discharged with con-

sible velocity and while in a vaporized condition into the air pipe M, Fig. 1, and by this operation draws in a sufficient amount of air for supporting combustion, which is mixed with the gasoline vapor and burns with a flame on top of the cast iron grating.

SPEED WATER CONTROL.—For the purpose of use on the motor car it is also desirable to have an automatic control of the supply of water; this is obtained in the White motor car by means of a pump which is directly connected to the engine, and which may deliver water either directly into the boiler or into the source of supply, depending upon the opening of a valve controlled by the steam pressure acting against a spring, as shown in section in Fig. 4. If the pressure rises above 400 lbs. or to any desired amount, the valve P is opened so as to return the water through the opening Q to the source of supply. If, on the other hand, the pressure is below the required amount, the valve is closed by the tension of the spring and is forced by the pump into the boiler.

It is noted by the illustration, Fig. 1, that no water gauge is supplied to the boiler and from the description of its operation it is seen that none is necessary.

The water circulating system is shown in Fig. 5, the generator being at the extreme right hand, the condenser at the extreme left, with the various pumps and pipe connections intermediate. The water tank or reservoir is shown at 27a, the two feed pumps at 23. These pumps are mechanically connected to the engine and take water from the reservoir 27a, and deliver this water either into the generator or into the source of supply, depending upon whether the by-pass valves with which both deliveries are provided are open or closed. The by-pass of one pump is controlled by hand by the valve 28a, and of the other pump by the pressure regulator which is located at 9 and has been fully described. A hand pump is provided at 17a which may be used to fill the generator when the engine is not running. The water is taken from the lower portion of the condenser through the pipe 34, by vacuum air pump 19a, and delivered to the reservoir. This pump is also kept in continuous operation by direct connection to the engine.

OPERATING CONDITIONS.—In the operation of the plant as applied to a steam car and provided with the automatic devices as described, the fuel and water are supplied as the demand for steam requires, with scarcely any attention on the part of the operator. Thus, for instance, if the steam pressure becomes excessive, the water supply is closed off by the water regulator, Fig. 4, which immediately causes the pressure to drop. If the temperature of the steam becomes excessive, which would soon be the case if the water supply were turned off, the full supply is cut off by the thermostat, Fig. 3, which soon reduces the temperature to the normal amount. On the other hand, if there is an excessive amount of steam drawn off, the pressure and temperature would change in the reverse direction, which would cause the automatic devices to turn on a supply of fuel and water to meet the demand.

For the purposes of meeting an extraordinary demand for power which sometimes happens in ascending a long hill, an auxiliary pump is kept in constant operation by the engine, the discharge of which can be made to go either into the boiler or into the source of supply by opening or closing a valve by hand, which is located convenient to the operator.

It is noted from this description that the operation of the White system is very different from that of the ordinary steam plant, and that the operator has little more to do than to control the motions of the engine, the steam generator providing steam when required. As used in the steam car the pressure is likely to fluctuate through wide ranges, for the reason that it will vary directly in accordance with the demand. The generator will supply high-pressure steam when a large amount of power is required and steam of low pressure when but little power is needed.

THE ENGINE.

The engine of the White steam car, as constructed for the 1907 car, is a vertical cross-compound with piston valve on the high-pressure and a plain slide valve on the low and which, except for its good workmanship, has no special points of merit.* It is provided with ball bearings throughout so as to render the mechanical friction as small as possible. The cranks are set quartering so that the engine as a whole has no dead center. It is provided with a simpling device under the control of the foot of the operator which will admit high-pressure steam into the low-pressure cylinder when necessary either for the purposes of starting or for obtaining a large amount of power for use in an emergency. The

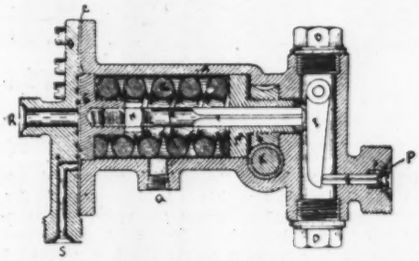


Fig. 4. Regulator for Controlling the Water Supply.

valves are driven from double eccentrics through the medium of Stephenson links and are operated in essentially the same manner as those in use in the ordinary steam locomotive, i. e., the point of cut-off can be changed and the engine reversed by a movement of the link. A view partly in section of the engine is shown in Fig. 6, which will be readily understood without further explanation. The engine is directly connected to various pumps already referred to which consist (1) of an air pump that is used to maintain an air pressure on the fuel tank for the purpose of regulating the feed of oil to the boiler, shown at P; (2) a vacuum air pump shown at R, also two boiler feed pumps shown at I and S. The one shown at T is provided with a by-pass controlled by the steam pressure as described, the other shown at S, with a by-pass controlled by hand. These pumps are simple plunger pumps with practically no mechanism to get out of order.

THE CONDENSER.—The steam system is provided with an air condenser which in its application to a motor car is placed at the front of the vehicle. It consists of a series of corrugated copper pipes with suitable header connections at top and bottom and is arranged to receive the exhaust steam into the upper header.† The condensed water falls by gravity to the lower header and is removed by a pump. The tubes are surrounded by air, which is circulated by the motion of the vehicle supplemented by the use of a fan located between the engine and the condensing surface. The condenser is furnished with a relief valve which opens to exhaust steam into the air in case the back pressure becomes of sensible amount. The condenser as previously applied to motor cars was not adapted to produce a sensible vacuum, its purpose being to conserve the water supply.

Recent improvements in the pumping system give a substantial vacuum from which a considerable increase in economy due to the vacuum is anticipated in the future. The motor car of 1907, it is expected, will maintain a vacuum of over 10 ins. at a speed of 20 miles per hour.

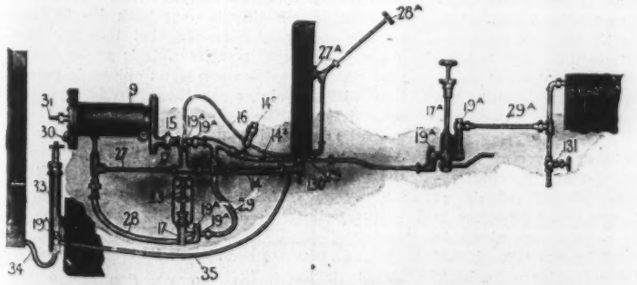


FIG. 5. THE WATER CIRCULATION SYSTEM.

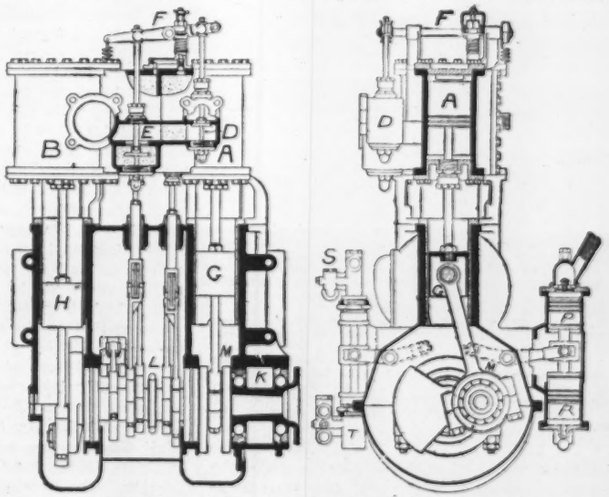


FIG. 6. SECTIONAL ELEVATION OF THE ENGINE.

TESTS OF THE WHITE STEAM PLANT.

Tests of the White steam system were made by Prof. C. H. Benjamin‡ in 1903 on a 10-HP. engine of the vertical cross-compound type with high-pressure cylinder 3 ins. in diameter, low-pressure cylinder 5 ins. in diameter, and with a stroke of 3½ ins. Its general construction was in many respects similar to the 1907 engine which has been fully described; it was not, however, provided with ball bearings. The test was made by essentially the same method as in a test conducted by the writer on the boiler and engine for the 1907 car, the results of which are given later. During the test the engine was operated at 675 r. p. m., the friction horse-power determined in Professor Benjamin's test was approximately 2, which, however, included that of an extra countershaft which was not required in the writer's test. Professor Benjamin's tests show a consumption of water per brake horse-power per hour varying from 12.6 to 19.9 and per indicated horse-power per hour an amount varying from 10.8 to 14 lbs.

These results compare fairly well with those obtained by the writer in a test of the boiler and engine for the 1907 car, in which with engine friction as 1.6 HP., a consumption of 11.96 lbs. of water per brake horse-power per hour and 11.54 lbs. per indicated horse-power per hour, were obtained.

Respecting his results Professor Benjamin states: "This is a remarkable showing for an engine of this size. When the fact is considered that ordinary simple engines use from 25 to 35 lbs. per indicated horse-power per hour, and that 12 pounds is considered good performance for triple-expansion condensing engines the remarkable nature of this performance is better understood."

THE PRESERVATION OF MINE TIMBERS.*

The experiment carried on during the past few months by the Philadelphia & Reading Coal & Iron Co., under the direction of a member of the U. S. Forest Service, has demonstrated that the preservation of mine props can be put on a firm commercial basis.

In the loss of mine timbers at least 60% are destroyed by decay and the remainder by crushing. The percentage charged to decay should be even higher, because many of the timbers which break have already been weakened by decay. Decay is probably the cause of 75% of all failures in mine timbers. The decay in props is principally caused by wood-destroying fungi. Warm, moist air, together with certain gases, found in mines, greatly favors the development of these fungi. Ventilation is an enormous factor. Timber in the vicinity of shafts and slopes where there is abundance of fresh air lasts longer than that deeper in the mines. The variation of moisture and temperature within mines is so wide that timbers may decay in eight months or may last several years. Timbers that are constantly wet or constantly dry last longer than those subjected to an alternation of these conditions.

Insects play a very considerable part in the destruction of mine timbers, and their destructive work appears to be in no way affected by the lack of light or by presence of gases. Creosote and carbolineum are effective insecticides and stop the work of the wood-borers.

Various materials and methods for preservative treatment have been tried, and up to the present time all have proved efficient. Only time will show which are the most satisfactory from the practical point of view. Applied with a brush, creosote and carbolineum give an excellent penetration in solid wood, frequently aver-

*For the cars built 1903 to 1906, engines of similar construction but with slide valves for both cylinders were employed.

†The condenser dimensions are as follows: For cars (1905-6) 74 tubes, 24.5 ins. long, with a total surface of 118 sq. ft. For car (1907) 65 tubes, 27 ins. long, with a total surface of 136 sq. ft.

‡Case School of Applied Science, Cleveland, Ohio.

*Abstract of an article in "Forestry and Irrigation" (owned and published by the American Forestry Association), prepared from information furnished by the U. S. Forest Service.

aging from ¼-in. to ½-in. Little difference in penetration has as yet been noted between creosote and carbolineum, though the latter seems better on absolutely green timber. All brush treatments were applied hot and in two coats. The second coat absorbed practically as much oil as the first.

Open-tank treatment has succeeded beyond all expectations. This consists of an immersion of the timbers for several hours in preservative and then allowing them to cool to atmospheric temperature. While the feasibility of the open-tank treatment has been demonstrated, there is much yet to be learned. The cost may be reduced by shortening the immersion and thus consuming less fluid. A very heavy treatment is not necessary. Seasoned and treated props, which were put in alongside of the old-style props, unseasoned and unpeeled, are as sound as ever, while the others are already showing signs of fungous growth and decay.

Most of the props in the collieries investigated are loblolly pine; Pennsylvania pitch pine furnishes 20%.; black and red oak, 10%. The loblolly pine comes from Maryland and Virginia, the pitch pine from north-central Pennsylvania, and the oak largely from New Jersey and Pennsylvania. The experiments have been mainly on loblolly pine, the wood most used.

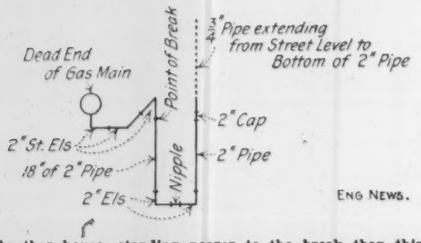
A REMARKABLE GAS ASPHYXIATION TRAGEDY AT WINOOSKI, VT.

The worst instance of asphyxiation by illuminating gas that has ever come to our attention was discovered at Winooski, Vt., on Jan. 6, 1907. All the members of a family of six, living in a house not connected with a gas main, met their death while asleep, gas having found its way into their house beneath the frozen earth. The family (of Geo. Devino) consisted of parents and four children, the latter all under six years of age. The following account of the cause of the tragedy has been prepared, at our request, by Prof. J. W. Votey, Dean of the Engineering Department of the University of Vermont, Burlington, Vt.:

About 50 ft. from the house which the gas entered is the dead end of a 4-in. wrought-iron main. This being the low end of the main it was capped and a drip constructed as shown by the accompanying sketch.

The object of this arrangement was to give the drip a flexible connection with the main. The break occurred at the male end of the third street elbow from the main. I am assured that the broken elbow was free from defects. The pipe was about 4½ ft. deep, the soil probably clay, and at the time of the trouble there was about 3 ft. of frost at the spot (it is now—Feb. 12—5 ft. deep in our streets).

The gas entered the cellar of the house at the nearest corner, and apparently did not follow up the sewer or water connections, which entered at another corner.



Another house, standing nearer to the break than this house, did not get any of the gas. The Devino house was not connected with the gas main. There is a report that there was an old ditch leading to the corner of the cellar where the gas entered, which might account for its passing as it did. Of course the frost prevented its escaping above ground.

I am sorry that I could not have seen the pipe when uncovered, but it appears to me now that settlement of the pipe was the only thing that could have brought any pressure upon that elbow; if the elbows were set up tight the connection may not have been as flexible as the company supposed. It is an open question whether the frost had anything to with the break; it was, of course, responsible for the gas entering the house.

We are also indebted to Professor Votey for information on another fatality connected with the gas distribution system of the Burlington Light & Power Co. This company, it should be explained, extended its service to the village of Winooski in the summer of 1906, by means of a 4-in. high-pressure main laid to and just across the Winooski River. On the morning of Jan. 24, 1907, a laborer employed by the company met instant death by falling into the pressure-reducer chamber at the terminus or Winooski end of the high-pressure main. The cover of the chamber had been removed and members of a repair gang were making ready to enter the chamber to stop a leak, when the laborer plunged in head first—possibly losing self-control through the escaping gas. Professor Votey has described for us the break at the reducer, as follows:

The gas is piped from the plant in Burlington under 5 to 15 lbs. pressure and then reduced for delivery to 2 to 3 ozs. In crossing the Winooski River the main is suspended from the sidewalk of the bridge, and being uncovered, is exposed to the extreme changes of temperature. The morning on which this break occurred a temperature of —30° F. was reported at Winooski. While some allowance was made in the arrangement of the piping in the manhole for the expansion and contraction, I think that this break must have been due to extreme contraction. The break occurred on the first elbow, as the pipe came through the wall on the high-pressure line. As the length of exposed pipe in crossing the river must be over 275 ft., the contraction from the summer temperature must have been over 2 ins. All of this work at Winooski was done last year, so this is its first winter. The company has had only a few leaks there, considering the amount of piping laid (7 miles).

From various sources we learn that there has been much complaint of gas leakage in Burlington, from extensions made last summer. A "ground joint, bolted together," was used on some of the work, and this is held responsible for a part of the leaks. Many trees (placed at a hundred or so) have been killed. A committee of city officials made a report the latter part of January, 1907, recommending that the gas be cut off the portion of Burlington in which the leaks had occurred. The report was accepted by the aldermen and the committee empowered to carry out its recommendations. Up to Feb. 12, nothing to that end had been accomplished. The gas company claims that it was not given a hearing before the investigating committee; also that leaks had been caused by the use of a road roller on the streets involved.

At a special village meeting, on Jan. 29, the voters of Winooski passed the following resolution:

That the main gas pipe be cut off at the bridge until spring, when the ground thaws out and all gas pipes be tested before turning the gas on, and that a committee of three be elected by this meeting to attend to this business at once, and the said committee to inspect said gas pipes before the gas is turned on again.

The committee called for was immediately appointed, but on Feb. 12 the gas had not yet been shut off.

TESTS OF THE HOLDING POWER OF RAILWAY SPIKES.

The efficiency or holding power of the spikes which hold the rails to the ties in railway track has been frequently discussed, and numerous tests have been made at various times to determine this power, or the resistance which they offer to forces tending to pull them out. In "Railway Track and Track Work," by E. E. R. Tratman, the general average for ordinary spikes is given as 3,000 to 5,000 lbs. in oak or pine and 800 to 1,800 lbs. in inferior woods, while for screw spikes the figures are 5,000 to 8,000 lbs. in oak and 4,000 lbs. in pine. Very much higher results have been obtained in tests, but in the book above mentioned it is stated that such results cannot be considered as likely to be obtained under the ordinary conditions of track and spiking. It will, of course, be understood that while the testing machine exerts a steady pull upon the spike, the rail exerts an irregular and jerking pull accompanied by vibration and lateral pressure which tend to loosen the spike, while the wave motion of the rail may develop a leverage instead of a direct pull.

A series of tests of the holding power of spikes has recently been made at the engineering experiment station of the University of Illinois, at Urbana, Ill., by Mr. Roy I. Webber, Instructor in Civil Engineering, and the results are given in Bulletin No. 6, recently issued by the Experiment Station. The averages of the results were high, but records of resistance to direct pull are of doubtful value as concerns track efficiency, for reasons stated above. The most important features of the tests were in regard to screw spikes and the resistance of ordinary and screw spikes to lateral pressure.

SCREW SPIKES.—Although the need of a more efficient rail fastening than the common spike for heavy track carrying heavy loads and traffic has been presented many times, very little has been done towards providing such an improvement. It is true that a small beginning has been made with screw spikes, which are very extensively and successfully used in other countries. Mr. Webber concludes that the screw spike in its present form is about twice as efficient as the ordinary spike, and that the efficiency could be increased by some slight changes in the form of the screw spike. We give below some extracts from the report in regard to screw spikes and to the Thiollier system of using a special metallic lining inserted in a thread tapped in the wood hole of the tie (Engineering News, June 21 and Aug. 23, 1906):

In countries where the screw spike is extensively used it has been perfected in its details, but in America it may be necessary to adjust the details to suit local conditions. The details are the diameter of the core, the projection and pitch of the thread, and the length of the thread. The soft steel from which the screw spike is made has an ultimate strength of about 66,000 lbs. per sq. in., so that the tensile strength of a spike ½ in. diameter is approximately 24,000 lbs. The ultimate compressive resistance across the grain of well-seasoned white oak is about 4,000 lbs. per sq. in., and experiments demonstrate that the thread of the spike in compressing the wood fibers increases the resistance about 50%. Therefore, taking 5,600 lbs. as the ultimate compressive strength of compacted white oak, and taking 17¾ ins. and ⅛-in., respectively, as the length and projection of the thread on the 5-in. spike, and making no allowance for frictional resistance between the core of the spike and the wood, the theoretical resistance would be 5,600 × 17¾ × ⅛ = 12,425 lbs. The average actual resistance obtained in white oak ties is 12,630 lbs., which agrees closely with the theoretical resistance.

The tensile strength of the screw spike is about 12,000 lbs. greater than the maximum resistance of white oak, and there are three ways in which the ultimate strength of the materials may be made more nearly equal: (1) Increase in length of threaded portion; (2) increase in projection of thread, the length and the diameter of the core remaining the same; (3) increase in projection of thread at the expense of the core, the length remaining the same. The pitch is assumed to be ½-in. in all cases, since it has been found in practice that this pitch gives better results than either a greater or smaller pitch.†

The experiments made with screw spikes having the Thiollier helical lining show that in hard woods the resistances for a pull of ½-in. are usually greater for the spike with lining than for the naked screw spike. But for pulls greater than ½-in. the reverse is the case.

LATERAL DISPLACEMENT OF SPIKES.—To determine the resistance of the spikes of lateral displacement, due to the pressure of the rail against the outer spikes, especially on curves, a special set of tests was made. A 100-lb. hammer on a 9-ft. pendulum rod was allowed to fall through a distance of 1½ ft., giving an impact blow of 150 lbs. upon the end of a tool steel bar, the opposite end of which was shaped to fit under the head of the spike. Five blows were delivered in each case, all the spikes being bent to a curve whose central point was about 1½ ins. below the surface of the tie. The ordinary spikes were slightly pulled from the tie, but in the screw spikes the thread prevented this movement. In view of the very general use of steel tie-plates and their effect in increasing the lateral resistance by distributing it over both the inside and outside spikes (which are tied together by the plate, if properly punched), it is to be regretted that no tests were made upon spikes in combination with tie-plates, as these would have given some idea of the value of tie-plates in holding the rails in position and so maintaining the gage. A summary of the results is tabulated below, and the report comments upon these tests as follows:

Tests of Lateral Displacement of Spikes.

	Ordinary 9/16-in. spikes.			Screw spikes.		
	Movement at—			Movement at—		
	1st blow, in.	5th blow, in.	Total, in.	1st blow, in.	5th blow, in.	Total, in.
White oak	0.21	0.09	0.70	0.09	0.10	0.39
Water oak	0.19	0.11	0.76	0.09	0.09	0.41
Black oak	0.21	0.06	0.71	0.11	0.09	0.43
Red oak	0.21	0.13	0.74	0.13	0.08	0.54
Elm	0.22	0.11	0.69	0.17	0.09	0.70
Beech	0.25	0.13	0.84	0.14	0.08	0.51
Poplar	0.27	0.12	0.82	0.17	0.13	0.65
Chestnut	0.32	0.23	1.23	0.16	0.09	0.66
Lob. pine	0.22	0.04	0.69	0.21	0.14	0.79

The ordinary spike was usually displaced more than the screw spike by each blow. This should be expected, since the common spike was smaller in cross-section than the screw spike, and also since the latter had better bond

*Bulletin No. 50, U. S. Dept. of Agriculture, Washington, D. C.

†Bulletin No. 50, U. S. Department of Agriculture, Washington, D. C.

...h the wood. While the use of the screw spike is ...ommended to American railways, it is thought that ... practice of the Bavarian State Railways could be ...lowed to advantage. These roads have adopted the ... of the screw spike on the gage side of the rail to ...ist overturning, but use two square spikes on the out... to resist lateral movement. This practice has been ...nd to give very beneficial results. The figures for the ...ts show that the lateral resistance of two ordinary ...kes is considerably more than that of one screw spike, ...d therefore if two spikes are considered as resisting the ...pact instead of one, the results will be in favor of the ...dinary spikes. Not only is this true, but the first cost ...r spikes would be reduced, since the screw spike costs ...out 4 cts., while the ordinary spike costs considerably ...s. The maintenance cost of either form of spike is ...most negligible. An item of interest is that out of 90 ...rew spikes used in the tests (and used several times) ...only two were broken.

CONCLUSIONS.—Upon the basis of the tests and the results obtained, Mr. Webber presents the following conclusions as a summary of the results:

(1) The maximum resistance to direct pull varies from ...,000 to 14,000 lbs. for screw spikes, from 3,000 to 8,000 lbs. for ordinary spikes when driven into untreated timbers, and from 4,000 to 9,000 lbs. for ordinary spikes when driven into treated timbers.

(2) The direct pull required to withdraw ordinary spikes ½-in. varies from 2,000 to 3,500 lbs. for untreated timbers, and from 2,500 to 3,500 lbs. for treated timbers.

(3) The direct pull required to withdraw ordinary spikes ¾-in. varies from 3,000 to 5,400 lbs. for untreated timbers and from 3,800 to 5,900 lbs. for treated timbers.

(4) Timbers having loose fiber structures have lower resistance to direct pull than timbers having compact fiber structures.

(5) The amount of withdrawal which must occur for ordinary spikes to develop the maximum resistance is less for soft woods than for hard woods.

(6) Spikes driven into treated timber offer a greater resistance to direct pull than spikes in untreated timbers, and the difference between this resistance for treated and untreated timbers is greater for soft woods than for hard woods.

(7) The difference in the resistance to direct pull for the different sized spikes in use (9/16-in., 19/32-in. and ⅝-in.) is very small.

(8) The resistance of ordinary spikes to direct pull varies directly as the depth of penetration, neglecting the tapering point.

(9) Blunt-pointed and bevel-pointed spikes have a slightly greater resistance to direct pull than chisel-pointed spikes.

(10) For withdrawals less than ¼-in., ordinary spikes which are driven into bored holes have a little greater resistance to direct pull than spikes driven in the ordinary way.

(11) The resistance to direct pull for re-driven spikes is from 60 to 80% of the resistance of newly driven spikes.

(12) The efficiency of screw spikes to resist withdrawal is nearly twice as great as that of common spikes.

(13) The resistance of ⅝-in. spikes to lateral displacement is slightly greater than that of 9/16-in. spikes.

(14) The resistance to lateral displacement increases with the depth of penetration, but the increase is negligible for depths of penetration greater than 4 ins.

(15) Screw spikes are more efficient than ordinary spikes in resisting lateral displacement.

A UNIVERSAL CURRENT METER.

By JOHN C. HOYT,* Assoc. M. Am. Soc. C. E.

In the stream gaging in the U. S. Geological Survey, in which the velocity of the water is generally determined by means of the current meter, considerable study has been given to the various types of meters, to determine the best for general use in this work. Owing to the general character of its investigation, the Survey needed a meter that can be used under a wide range of conditions, both as to the character of the stream to be measured and the facilities for making the measurements. All of the meters in use at the time of starting the work had been developed for use under some special condition, and although giving good results under such special conditions, they were not adapted for universal work. It was, therefore, necessary to design a universal instrument.

The meter thus designed is shown by Fig. 2, and is commonly known as the Small Price Electric Meter. In its construction the vertical axis, conical cups and point-bearing of the Price acoustic were used as a base. It consists of a U-shaped yoke, carrying a wheel made of conical cups set with their axes tangent to a circle. The wheel is supported and revolves in a horizontal plane on a conical point bearing. The yoke and wheel form the head of the meter and are counterbalanced by a two-bladed tail that is utilized, also, to keep the meter headed in the current. The meter is hung pivotly a little above the center of gravity in the stem, provision being made for a slight tilted motion. Stability in the water is maintained by lead weights. Under ordinary conditions it is suspended by a No. 16 double conductor insulated cable, which also provides for the transmission of the current to the sounder.

The sounder, which indicates each revolution of the wheel, consists of either a telephone receiver or an ordinary buzzer excited by either a dry or wet cell. The suspending cable carrying the sounder is attached to the meter by two small insulated wires, which are connected to the stem and through a hard rubber bushing to the contact spring in the head. The upper end of the axis on which the cups revolve carries an eccentric post that is arranged so as to bear against the contact spring once during each revolution of the cups, thus closing the circuit and exciting the sounder. The head that carries the shaft and contact spring is made water-tight, thus insuring that the contact shall be free from disturbance. An adjustable device is arranged so that the recorder will indicate only each fifth revolution. This makes the meter suitable for measuring both high and low velocities.

The meter is especially durable; it is light and can be packed into a small box and readily carried. It can be used with equal ease in wading measurements or in measurements from bridges or cables 50 ft. above the water. It will measure with equal accuracy velocities ranging from 0.5 ft. to 15 ft. per sec., but is not reliable for velocities lower than 0.5 ft. per sec. Results of tests give a discharge as measured by the meter within a few per cent. of that measured by a sharp-crested weir.

Each meter is rated to determine the relation between the velocity of the moving water and the revolutions of the wheel. In rating the meter, it is driven with a uniform motion through still water for a given distance, and the number of revolutions made in this distance are noted. From these data, the velocity per second and the corresponding number of revolutions per second are computed. Determinations are made at various speeds, the results of which, when plotted, define the rating curve for the meter. Theoretically, the curve should be a straight line, as the wheel of the meter passes through the water in the same way as a wheel passes over the ground, that is, neglecting friction, in going a certain distance it will make practically the same number of revolutions regardless of speed. Fig. 2 shows the ratings of a number of the principal types of meters now in common use. These ratings were made at the U. S. Geological Survey rating station at Chevy Chase, Md.

*Engineer, U. S. Geological Survey, 1330 F St., N. W., Washington, D. C.

A STEAM-TURBINE OF 24,000 HP. is being built at the Mannheim works of Brown, Boveri & Co., according to the "Schweizerische Bauzeitung." The machine is to be installed in the Krupp rolling-mills at Rheinhausen, Germany.

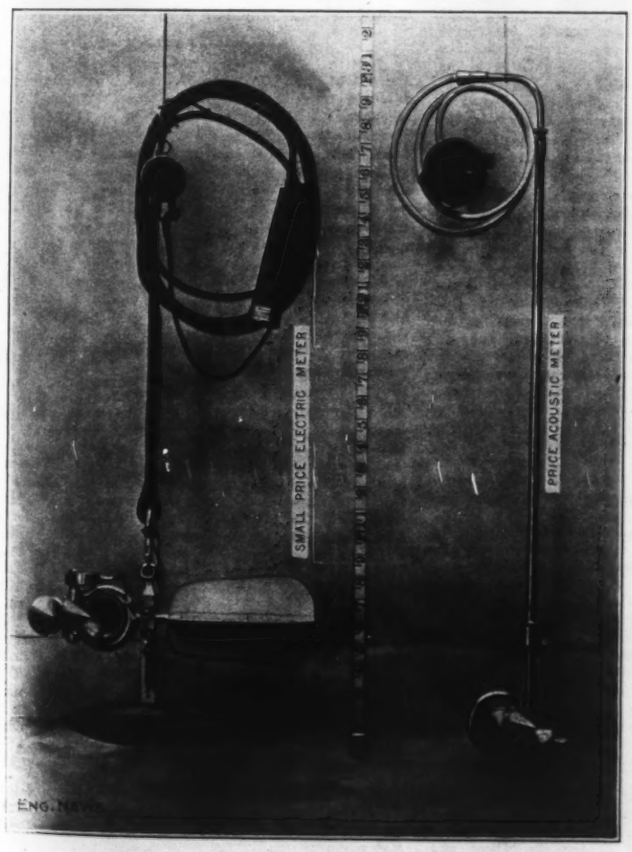


FIG. 1. PRICE CURRENT METERS FOR STREAM GAGINGS.

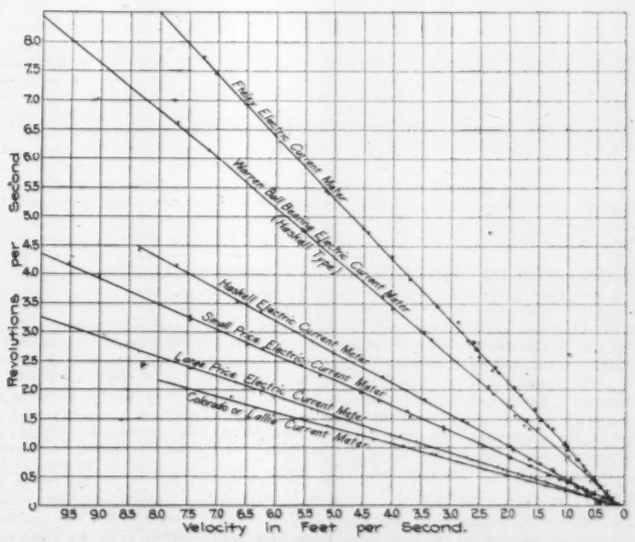
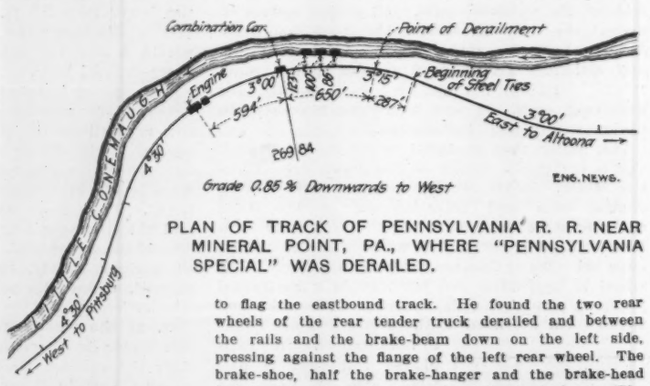

Revolutions per Second
Velocity in Feet per Second.
Fteley Electric Current Meter.
Warren Ball Bearing Electric Current Meter (Haskell Type)
Haskell Electric Current Meter.
Small Price Electric Current Meter.
Large Price Electric Current Meter.
Colorado or Lalla Current Meter.

FIG. 2. RATINGS FOR TYPICAL CURRENTS METERS.
(Ratings made by the U. S. Geological Survey at its Rating Station, Chevy Chase, Md.)

REPORT ON THE DERAILMENT OF THE "PENNSYLVANIA 18-HOUR SPECIAL" AT MINERAL POINT, PA.; REMOVAL OF STEEL CROSS-TIES.

Immediately after the derailment and destruction of the Pennsylvania R. R.'s fastest train between New York and Chicago, the westbound 18-hour "Pennsylvania Special," on the evening of Friday, Feb. 22, the railroad company had an investigation of the accident made. The very unusual course was taken of making public the report rendered by the investigating committee. As there was apparently no element of negligence involved in the accident, the investigation deals wholly with mechanical facts and actions. It establishes to a high degree of probability that the train was derailed by a fallen brake-beam on the rear truck of the tender, derailing the rear tender axle and tearing up the track so that the four following cars were also derailed.

The track at the point where the wreck occurred was laid with steel ties, the railroad being engaged in trying out various types of substitute for wooden ties by laying them in the track at different points on its lines. It appears that there is no evidence to indicate that these ties contributed to causing the derailment, so that the fact of the accident's occurring at this particular trial section is merely a curious coincidence. The investigating committee finds, however, that the consequences of the derailment were more serious than might be expected on track laid with wooden ties. The uninjured part of the steel-tie track was found in first-class condition, so that it may be assumed that the track in the path of the derailed vehicles was also in good condition just prior to the wreck. Yet throughout the length of travel of the locomotive after the derailment, about 1,250 ft., on 3° 15′ and 3° 0′ curve, the outer rail was pushed out, forced the heads of the clip bolts off, and was shoved to and off the ends of the ties, the rail itself being so little injured that much of it was put back again in repairing the track. Such an action should hardly be expected on wooden ties, with the greater friction between rail and tie. In fact, in the very similar accident at Bronx Park on the New York Central & Hudson River R. R., a week before, on about the same curvature, at about the same speed, with a train of similar weight, but on a wooden-tie track, only one length of outer rail was found displaced. The committee concludes, therefore, that it is advisable to remove the remaining steel ties and replace them by wooden ties. This recommendation, we understand, is to be carried into effect, upon order of General Manager W. W. Atterbury.



PLAN OF TRACK OF PENNSYLVANIA R. R. NEAR MINERAL POINT, PA., WHERE "PENNSYLVANIA SPECIAL" WAS DERAILED.

The report of the investigating committee follows:

Mr. W. W. Atterbury,
General Manager.

Dear Sir: Your Committee appointed to investigate the cause of the accident to train No. 29 west of Mineral Point, on the Pittsburg Division, on the night of February 22, arrived on the scene about four o'clock on the afternoon of the 23d. Previous to our arrival No. 3 track had been rebuilt for the entire stretch and was in service. The wreck occurred on the section of track laid with experimental Carnegie steel cross ties, the first indication of derailment being at a point 287 ft. west of the east end of these ties, and on a 3¼° curve to the left. The track had been torn up from this point a distance of 1,244 ft., where the locomotive stopped. The plan which accompanies this report indicates the position of the locomotive and cars as they were found immediately after the occurrence of the accident. All of the wheels of the locomotive and tender were on the track according to the best evidence obtainable, except the two rear wheels of the rear tender truck, which were off the track and lying between the rails. The combined car stopped 594 ft. east of the locomotive and remained on its trucks, although all the wheels were derailed. The three Pullman cars were found on their sides down over the bank in the river bed, which was covered with ice. The high rail was found clear of the ties on top of the embankment, the outside bolt fastenings had been sheared and snapped off the entire distance of 1,244 ft., the point the locomotive stopped. As evidence of the force with which these bolts were broken off, some of them were found in the river bed about 200 ft. from the track. The steel ties were badly crushed. We also found that the inside clips on the low rail had been badly damaged by the derailed wheels, and these had also broken pieces out of the base of the rail at intervals, although it was not thrown out of its original position. At the point of the accident, the first splice-bar ahead of the point of derailment, on the high side, was broken through the second bolt hole and bent outward by a lateral thrust.

We then went to Altoona, interviewed the engineer and fireman, and examined the locomotive and trucks in the engine house. The engineer's statement was that he had been making a good run down the Western Slope, but at no place was running at an excessive speed; and before striking the stretch of steel ties, he made an 8-lb. reduction of his air to steady the train, as was his custom. He states positively that before he applied his brake, he was not going more than 50 miles an hour, and record taken from the train sheet corroborates his statement. An instant after he applied the air, he felt the emergency go on, and, thinking it was a burst hose on the train, released his air and looked back, when he saw the cars going over the bank. He re-applied his brake and as soon as he stopped, got down to examine the locomotive; the fireman going ahead to flag the eastbound track. He found the two rear wheels of the rear tender truck derailed and between the rails and the brake-beam down on the left side, pressing against the flange of the left rear wheel. The brake-shoe, half the brake-hanger and the brake-head had been lost from the left side of the brake-beam. The beam was supported on the right or high side by its brake-hanger, and the shoe was in place. An examination of the locomotive in the engine house afterwards corroborated the engineer's statement, a piece of the brake-hanger and part of the brake-head having been subsequently found along the track, the brake-head 500 ft. and the half of the brake-hanger 264 ft. back of the point where the locomotive stopped. No part of the brake-shoe has been recovered, although search was made for it. This is not surprising, however, considering the fact that the roadbed was badly torn up for a distance of five or six hundred feet and had been replaced. We afterwards made an examination of the brake-beam and found that the end on the left side had been caught under the flange of the wheel, as the mark made by the flange plainly indicated, although the abrasions on the end of the beam were hardly sufficient to indicate positively that the beam came down at the time of derailment, and had dragged the entire distance. It should also be noted that an examination of the two parts of the broken brake-hanger, which was rectangular in shape and made of one piece of ¾-in. iron, showed that one corner of it had been worn by the flange of a wheel at some previous time, although in this condition it was strong enough to withstand ordinary service.

It seems to be the impression of those division people who were first on the ground, that the accident was primarily caused by the brake-beam falling down on one side. At the same time it is impossible for us to definitely attribute the cause of the accident to that source. A portion of the torn-up track had been renewed with wooden cross-ties before we reached the ground, and was in service for trains at slow speed, so that we are unable to definitely attribute the cause in any way to defective track. We made a careful inspection of the track of steel tie construction ahead of the portion damaged by the wreck, and therefore not affected thereby, a distance of about half a mile, and found it in first-class condition; all the outside clips being tight against the base of the rail, the bolts on the inside, with few exceptions, being tight, holding the clips in condition; the line and surface being as nearly perfect as it was possible to get track, and the whole mass of steel cross-ties frozen tight to the ballast, and not the slightest indication of shifting in any d whatever; nor was there the slightest indication of ment on the top of the steel cross-ties by any rails for the entire distance.

If the accident had occurred on the section of laid with wooden cross-ties, it is our judgment th injury would have been done to the track structur after the one pair of wheels of the tender of locomotive was derailed, the bolts of the outside high rail were snapped off throughout the entir tance the tender was derailed, the rail on thi having been shoved out and off the end of the cr A large portion of this rail was simply lifted back position and with new bolts and clips again pla service, as there was little injury done to the steel ties west of the point where the combined car stop

We are unable to definitely account for the ca the accident, but the best reason for it that we advance is that at the point where derailment occ some foreign material became wedged between the f of the left rear tender truck wheel and the inside low rail, which, on account of the rigidity of steel ties and fastenings, and on account of the temperature, the temperature being 12° below zero, duced sufficient lateral force to shear the bolts on outside rail. It is possible that this foreign subs was the brake-shoe or a part thereof, which, as b stated, has not been found. We are informed that usual inspection was made of the locomotive before le ing the engine house, and the gage of the wheels w measured in our presence after the accident and fou to be correct.

We are of the opinion, on account of the lack of positive evidence as to the cause of this derailment, and on account of the fact that the damage subsequent to derailment was more serious than would have been the case with wooden ties, that the remaining steel ties should be removed.

Respectfully,
H. M. Carson, Asst. to General Manager.
A. C. Shand, Chief Engineer.
L. R. Zollinger, Engineer Maintenance of Way.

Feb. 26, 1907.

It may be pertinent to note that six days after the Pennsylvania derailment, the same cause produced a fatal wreck on the Baltimore & Ohio Ry. near Connellsville, Pa. A westbound passenger train, said to have been running at a speed of 40 mi. per hr., was derailed at 6 p. m., Feb. 28, "by some part of the engine mechanism becoming loosened and dropping to the track, throwing the train from the tracks," according to a statement of General Superintendent R. Finney.

A STEEL BOX CAR has been built for experimental purposes at the Union Pacific Ry. shops at Omaha, Neb.; the designs being prepared by Mr. W. R. McKeen, Jr., Superintendent of Motive Power. A single 15-in. I-beam forms the center sill, and to its ends are riveted pairs of 12-in. channels forming the draft sills. There are no independent side sills, but the side plates are extended below the floor to form a fish-belly girder, the depth at the door opening being 22 ins. The posts are 4 x 3½-in. angles, and diagonals run from the end sill to top of first post, and from the end of bolster to the door post. Horizontal diagonal angles run from the center sill and form a herring-bone arrangement. The side and end sheets are of No. 11 gage. The car is of 100,000 lbs. rated capacity, 40 ft. long over the end sills. Its weight is 37,800 lbs., as compared with 42,200 lbs. for the Union Pacific Ry. standard wooden box cars.

A TURBINE WITH FIVE BUCKET-RINGS in a single wheel, for close adjustment to varying discharge, has been built by Piccard, Pictet & Co., of Geneva, Switzerland, for the hydraulic power plant at Avignonnet-sur-le-Drac, France. The turbine is intended to meet conditions of variable head, and was designed to give good efficiency at the different discharge rates called for to develop its rated power under these conditions. The wheel, 54 ins. in diameter by 39 ins. wide, has four identically similar bucket-rings, and a fifth of closer bucket-spacing and different bucket-angle (for low head at high water). The five-part ring is cast in one piece, and is bolted to a hub in such a way as to place the similar rings symmetrical to the hub. The draft-tube is double, one branch on either side of the hub, and the draft-tube pressures are equalized by perforations in the hub. A steel cylinder-gate moving between the guide-vanes and the wheel controls the discharge. The wheel has a maximum power capacity of 1,750 HP., at 250 r. p. m., and will work under heads varying up to 75 ft.

THE CAPE COD SHIP CANAL CONSTRUCTION is to be carried on under joint supervision of the Railroad Commission and the Harbor and Land Commission of Massachusetts.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
ATLANTA: Candler Building
RUDOLF MOSSE, BERLIN AND HAMBURG, GERMANY

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Entered at the New York Post-Office as Second-Class Matter.

The New York Railroad Commission has done well in setting on foot an examination of railway drawbridges within the State. The report made as a result of this investigation is printed in full elsewhere in this issue. It is noteworthy that this investigation was set on foot immediately following the Atlantic City disaster last November. The rules recommended by the Board respecting the movable rails at the ends of drawspans state that the movable rails must be bolt-locked in position and the bolt lock must be interlocked with the signals governing the approach to the draw. The Board also specifies that all draws must be protected by derailing switches interlocked with home and distant signals and the interlocking is required to be such that when the draw is closed, end wedges inserted and draw locked, movable rails lowered to place and bolt-locked down—then derails can be closed, home signal cleared and distant signal cleared, and that the above described movements can only be done consecutively in the order named.

Another contribution to drawbridge design is a paper by Mr. C. C. Schneider, M. Am. Soc. C. E., to be read before the Society on April 3 and published in the "Proceedings" for February. In this paper Mr. Schneider offers a set of specifications for movable bridges in which we note the clause that "bridges carrying railroads shall have at each shore end an automatic signal, and such signals shall be arranged so that the signals cannot be set to indicate a clear track until the bridge is closed and the rails are in their proper position."

This is sound doctrine and we hope will receive due attention from railway companies which have drawbridges not subject to the jurisdiction of the New York Railroad Commission.

What is a railway? Mr. Harriman's definition appears to be that it is a machine for stock speculation. It is now a matter of public record that the directors of the Union Pacific R. R. authorized the mortgaging of the property for $100,000,000, and gave the money to the President of the company for the purchase of stock, empowering him to buy and sell as he saw fit. Since then the Union Pacific has been buying stocks of railway companies, literally from the Atlantic to the Pacific. It is said that the stockholders have profited by the speculations. Incidentally it is believed that the market position which Mr. Harriman has secured by control of this fund has enabled him to reap very large profits on his own account. Just where he drew the line between his own interests and the stockholders' interest is not altogether clear.

Even if the fund were administered with absolute regard for the stockholders, and for them alone, public opinion is unanimous in condemning such misuse of corporation machinery. A common carrier has no business to jeopardize its solvency by carrying on a Wall St. speculation on the side. Suppose the stockholders of a paper mill or a machine shop were asked to mortgage their property to raise funds with which their President could buy and sell stocks for their benefit. They would at once reply that their investment was in a manufacturing business and not in stock speculation.

The common and flagrant misuse of corporation privileges must soon result in legislation which will rigidly restrict or even prohibit the holding by one corporation of the stock of another. Were this privilege abolished it would put a stop to one of the favorite plans of defrauding stockholders for the benefit of those who hold control.

There has been for two or three months past a chorus of railway presidents complaining that the public will not invest in railway securities because of anti-railway legislation at Washington and elsewhere. The Union Pacific and Chicago & Alton revelations are a full and sufficient reply to all these statements. When our financiers adopt the plan of giving the small stockholder all his property earns, and not as little as they can and still keep outside of prison bars, there will be no lack of funds for legitimate railway development. The investing public fears High Finance more than it fears the President or Congress.

The unsatisfactory outcome of the recent examination of candidates for the position of Chief of the Bureau of Water of Philadelphia gives rise to the question whether so important an executive engineering position ought to be filled by a civil service examination. Of 25 candidates who took the examination, only one passed, and he by a margin of but 0.1, the minimum requirement being a marking of 70. Of the 24 candidates who failed to pass, 2 received marks between 70 and 60, 1 between 60 and 50, 10 between 50 and 30, and the remaining 11, marks below 30. The (written) examination questions were published in our issue of Jan. 3, 1907. They were prepared and the examination was conducted by Messrs. John C. Trautwine, Jr., M. Am. Soc. C. E., Major Cassius E. Gillette, and Wilfred Lewis, M. Am. Soc. M. E. Assuming that an examination for the position was to be held, we do not think that reasonable exception could be taken to the questions asked; and it goes without saying that with such men as examiners the examination would be fairly conducted. Why, then, was the result so unsatisfactory? Two answers, at least, can be given: (1) An examination of this sort does not appeal to most men competent to fill such an important position, because men of experience are likely to be rusty on definitions and formulas, and because it is difficult to bring out a man's qualifications for an administrative office by means of an examination; and (2) because under American political conditions it is generally deemed necessary to demand that candidates for a municipal position must be residents of the city in which the vacancy occurs. The first of these answers might be expanded at length, but that seems unnecessary. As to the second it is obvious that a man may best become fitted to administer the water-works of a large city by having filled either a subordinate position in the water-works there or elsewhere, or through having been at the head of a water department in another city. Since few subordinates in a given city are likely to be able to fill the position of chief, the number of candidates with local experience must necessarily be small. But if a position like this one at Philadelphia had been thrown open to men of experience throughout the whole United States and due publicity had been given to the vacancy, many candidates with experience in similar positions might have been expected. Out of the many candidates, foreign or local, it is possible that a considerable number would be placed upon the eligible list, and then great weight might be given, in making a choice from the eligibles, to their previous experience. But when only one or a very few men pass, the chances are that previous experience can be given but little weight in the final choice. It may be noted in conclusion that the one successful candidate in point of marking, if we are correctly informed, was declared ineligible because of non-residence, although for a number of years and until quite recently he had been employed in the Philadelphia Bureau of Filtration, both in the construction and operation of the new filters, and therefore gained much experience that would have been of value to him and to the city had he secured the appointment. This ruling of ineligibility, simply because the candidate has lost his legal residence in the city, emphasizes the disadvantages of the local citizenship requirement. It can work no injustice to the candidate who did pass the examination to state that his experience in executive positions was limited; that this should have been true of the only candidate who passed the examination affords further illustration of the difficulties besetting the civil service examination as a means for selecting candidates for chief of an important municipal engineering bureau. As has often been urged in discussions of this general subject, it is very likely to be some young man of more knowledge than experience who heads the list at civil service examinations. This makes it all the more desirable, therefore, to make the conditions of candidacy, and particularly those of residency, as broad as possible.

It was a surprise to all, laymen as well as railway men, when the Pennsylvania Railroad last week made public a report by a committee of its own officials on the circumstances and causes of the Mineral Point derailment. The surprise lay in the novelty and therefore the unexpectedness of the action. Railway managers have in the past made it a rigid practice to view a wreck on any line as the private business of that line, something with which the public had no concern. Seekers after information were in all cases sent away with a minimum or an absolute zero of fact, and with the clear impression that their curiosity was considered rather impertinent. Where the accident bore on its face the stamp of individual negligence or error, the statement was vouchsafed, perhaps, that the employees connected with the accident would be questioned, and the guilty discharged. Where the causes were unusual or not at once evident, the terms "mysterious" and "unpreventable" were freely used to characterize the occurrence. Where inadequate equipment or bad method might conceivably be involved, there were forthcoming ready declarations that every detail of the service and all appliances were the best known and had never before given even a suspicion of trouble. The company courted publicity—to the extent of giving out the names of the dead and injured; but to let the public have the inner facts and circumstances of the accident was not to be thought of.

Such conditions as these have been universal. They have led to a gradually growing belief that a public tribunal for the investigation of railway accidents by expert knowledge was a pressing necessity. In our issues of Nov. 15 and 22, 1906, we gave direct expression to this belief, and urged the need of such a tribunal in the interests of improved railway practice. In England the Board of Trade, a national body, makes thorough investigation of all railway accidents, and by its public reports instructs both the railway world and the public at large in regard to cause and responsibility; the lesson of each accident is thus spread before the eyes of all to profit thereby. In our own country, in the absence of competent public investigation, accident after accident from a single cause may occur and the lesson be wholly lost. We advocated, therefore, the establishment of a system similar to the English, by the creation of an expert board

under the auspices of the federal government to investigate railway accidents and publish its findings. Since we made this argument a period of remarkable frequency of serious wrecks has been experienced, and the demand of the people for methods ensuring better protection has multiplied.

Railway managers, too, it seems, have felt the need for a changed system. Whether this is the result of the public agitation or a result of recognizing the truths behind this agitation, we need not attempt to inquire. Not long ago the manager of one of the largest systems stated publicly his belief that after every railway wreck the full findings as to the cause and responsibility should be made public, if only for the great disciplinary effect of this publicity upon operating employees. The action of the Pennsylvania Railroad in the case of the Mineral Point wreck is an expression of a similar view. When the report in question was made public, it was accomplished by semiofficial assurances that a similar course of publicity would be generally followed in future. If this proves to be true, and if other railways follow the example, we will be in possession of some of the advantages of the government board system. The great feature of publicity, even though it be publicity of ex parte evidence, will have achieved a new recognition.

It is perhaps only natural that this step forward should have been made in a case of quite impersonal interest, one in which no blame or responsibility fell upon an employee or the organization. At the same time we must recognize that such a case is not a final demonstration of the value of the innovation. We must await an instance in which there appears the element or error on the part of an employee or a department of the company. At the time of the Atlantic City drawbridge wreck, last October, this same railway, the Pennsylvania, appeared before the public with vehement assertion that the construction and equipment involved were in every way perfect—in the face of the fact that the wreck directly resulted from an incomplete interlocking system; that, of course, was prior to the recent change of policy. But the new policy will not have proved itself until tried with success in a case of that kind.

THE NEW YORK CENTRAL ACCIDENT INVESTIGATION AND THE ACTION OF RAILWAY TRAINS ON CURVES.

Many questions as to the action of railway trains on curves have been brought into prominence during the last fortnight by the fatal derailment of an electric suburban train on the New York Central in the outskirts of New York City on the evening of Feb. 16, followed by the derailment of the Pennsylvania's famous 18-hour New York-Chicago express near Johnstown, Pa., on Feb. 22. The New York Central accident has been investigated by a coroner's jury and by the New York Railroad Commission. Much of the inquiry has been concentrated on the possible causes of derailment on a curve at high speed. The questions asked and answers given, together with the comments of the daily press, have betrayed such a widespread ignorance of the whole subject of "railway curve mechanics" that some discussion in this place seems called for.

Let us say at the start that the most notable error of the zealous attorneys who have conducted these examinations has been the assumption that their questions as to safe speeds, stresses, etc., were capable of an exact answer. They assumed, doubtless in all sincerity, that the railway engineers could accurately compute the stresses in the rail and its fastenings produced by trains of a given weight and speed, and that track fastenings and train speeds are actually in good practice proportioned with the aid of such computations.

Naturally, witnesses assailed by questions of this sort were obliged to confess their inability to answer them, and in consequence made a poor showing on the stand. As a single illustration of the course of the investigation, we may take the following excerpt from the proceedings before the Coroner, as reported in the New York "Times" of Feb. 21:

Chief Engineer George W. Kittredge, having general charge of the construction of the tracks, testified that there was no lateral pressure against the rails at the curve at a speed of 46 miles an hour; that there would be lateral pressure increasing with the weight of the train and its speed if it was above that rate, but he had not figured out precisely what that additional pressure would be or whether the track at the curve would bear it. He had depended on his general experience in the matter, he said.

Chief Engineer Kittredge gave a detailed description of the construction of the track on the curve, and explained the force against the rails under varying conditions. He said that as the speed increased the pressure increased proportionately with the weight of the train. If the speed were 50 or 60 miles an hour the pressure would be correspondingly greater. If one continued to increase the speed and the weight of the train, he said, it eventually would come to a point where the spikes would break. "Is it possible," said the Assistant District Attorney, "to calculate scientifically and mathematically the resisting power of each rail and each spike so as to learn exactly the lateral pressure each rail will withstand without breaking?"

"Yes," said the Chief Engineer.

"It is possible, also, is it not, to calculate the lateral pressure against the spikes exerted by a train of given weight going at a given rate of speed, say 50 or 60 miles per hour?"

"It is."

"In your department had you a record of the power of the spikes that held the rail that was displaced the night of the wreck?"

"Not that I know of," said Mr. Kittredge.

"Any record showing the particular pressure of an electric locomotive going around that curve at any speed above 46 miles an hour?"

"Not that I know of."

Mr. Kittredge declared, however, that he had made such a calculation since the accident, and the Assistant District Attorney asked him to tell about it. He said that spikes placed as the spikes were at the curve in question would not shear off, as those spikes did, unless a locomotive the size of the one on the express that night struck the curve at a speed of 123 miles an hour. He submitted figures to prove this.

"Now, Mr. Kittredge," the District Attorney said, "this question of the strength of these rails at the curve was perfectly capable of an easy mathematical calculation, such as you have made in a single night, and you did not do it until I requested you to yesterday?"

"No," said the Chief Engineer, "we hadn't."

"Yet you were perfectly sure that the tracks there would not break under the speed that was possible for these electric locomotives to make?"

"Just as sure as I am that I am sitting here."

"You rely not on scientific examination but on your experience?"

"Yes."

"What then caused the accident?" asked Mr. Smyth.

"That I cannot tell," said the witness. "But I think it was not the speed of the train or the weight of the train or the elevation of the track. Everything about the construction was correct, absolutely. For explanation we must look for something beyond that. I have no idea what it was."

"But, Mr. Kittredge" broke in Coroner Schwannecke, "you say that with those things perfect as they were, the train would have to go at a speed of 123 miles an hour to break the spikes. The spikes were broken, every one of them, as I myself saw. Do you mean to say that the train was going 123 miles an hour?"

"No," said the Chief Engineer quickly; "as I said we must look for something else as the cause."

"Why is it," said a juror, "that when they relaid the track they put in two spikes where there was but one before? We saw that, ourselves."

"I don't know," said Mr. Kittredge. "That was not done at my order. Yes, two spikes are twice as strong as one spike, of course."

It is unfortunate that Mr. Kittredge, in answer to the question, "Is it possible to calculate the lateral pressure against the spikes exerted by a train of given weight going at a given rate of speed," did not answer promptly and definitely "No"; for such an answer would have been in accord with the exact facts. We do not mean by this that it is impossible to make calculations bearing on this matter, and many such calculations have been made. These calculations, however, involve a number of assumptions, which may vary largely from actual conditions in a given case, and the final result obtained is valuable only as an aid to expert judgment.

To illustrate only a single one of the difficulties involved in computation: When we have finally computed the theoretical pressure of the outer wheel flange against the rail, we this pressure is applied at the side of head, some 5½ ins. above the base of the the resultant of this lateral force and the on the wheel may either tip the rail against the spikes, according to the of friction between rail and tie. This in friction coefficients is alone sufficient any computation of spike pressures of proximation.

It is very unfortunate that this matter not be presented to the public in the right Taking their cue from the questions at the coroner's investigation, the newspapers have filled the engineers and officers of the New York Central with such headlines as "Criminal Neglect Explains Central Wreck"; "Disaster Declared to be Due to Velocity and Weight of Motors on Curve"; "Speed of N. Y. Central Trains Fixed by Guess"; "Engineer Kittredge and Other Officials Admit No Mathematical Calculations of Any Kind Were Made"; "No Scientific Estimate Was Made as to How Much the Rails Would Stand."

Reading such headlines as these, the public is not slow to believe the worst concerning those on whom responsibility for the safety of the traveling public is placed. In the public mind the New York Central officials are convicted of ignorance and incompetence. The result is to deepen the prevalent enmity of the public toward railway corporations. Meanwhile the main result which ought to attend the investigation—ascertaining the causes and the practical lessons to be drawn for the betterment of railway practice and prevention of similar accidents—is wholly lost sight of.

We have spoken recently and strongly concerning the need for Government investigation of railway accidents. This New York Central disaster illustrates how such Government expert investigations would serve to protect competent officers from undeserved blame.

The fact is that to set a coroner and his legal assistants at the task of unraveling all the circumstances regarding the cause of a railway accident is about as likely to lead to intelligent result as would be the case were the same set of men required to determine the cause of breakdown of a complicated piece of textile machinery.

Returning now to the matter of "curve mechanics," we wish to emphasize the fact that even among practical railway officials in the engineering and motive power departments, comparatively little is known regarding many of these matters concerning which the newspapers and their correspondents have been speaking with such confidence.

As an illustration, we may take the idea, extensively promulgated when it was supposed that the last car of the New York Central train was first to be derailed, that the last car of a train is more likely to be thrown from the track in rounding a curve than any other because it is like the last boy in a string of boys who are playing "snap the whip"!

This sort of mechanics appeals to the layman, and for a day or two one would judge, from the comments in the newspapers, that the railway officials were seriously negligent in not appreciating that the last car of the train was likely to be "snapped off" in rounding the curve. Of course when it was determined that the last car was not the first to be derailed, the "snapping off" theory was dropped.

Take this question, whether the last car of a train is more liable to derailment than any other, which the newspaper reporter answers so easily. The railroad officer does not find its answer at all easy. The practical answer is, of course, that operating experience has never shown any such greater liability to derailment of the last car, sufficient at least to be noticeable. For an answer based on analysis of forces, the "snap the whip" theory is of course thrown out, since the string of boys does not follow a true circular path like a train of cars. To find whether the wheel flange pressures are actually greater on the last car than the first is not at all a simple matter. The last car

train rounding a curve differs from the ... only in the fact that it has no pull acting ... rear of its body due to the traction of cars ... This pull tends, in a slight degree to ... the centrifugal force due to the curve, ... be useful in a measure to steady the ... side swinging which is apt to occur on ... track and which doubtless adds to any ... derailing tendencies. This pull of ... ars behind, however, affects mainly the ... truck of the car; and the front truck ... car, on account of the friction of cen... and side bearings, is the one most liable ... railment. The amount of this friction will ... to be determined before the theoretical dif... in flange pressures tending to derail the ... car and other cars of a train can be com...

...ctically, we may add, it makes no particular ...rence whether the last car is or is not more ... to derailment than any other, since the ...man's plan of ameliorating the horrors of ... collisions by leaving off the last car of every ... is not feasible.

The underlying idea in the investigation and in the current discussion has been that it is possible by "scientific" methods to exactly compute the safe speed of a train on a curve and the spiking necessary to hold a rail safely in place to carry trains of given weight and speed; in short, that the stresses in track and in car wheels and trucks under given conditions can be figured out and provided for in the same way that an engineer computes stresses and proportions members in a bridge truss. Most of our readers understand that this is absurd, and the reason it is absurd is because we are dealing with a complicated problem of practical dynamics and not a simple problem of statics.

Very likely the idea that curve stresses could be accurately computed has grown from the knowledge that superelevation of the outer rail on curves *is* accurately computed from the centrifugal force. The little learning that is proverbially so dangerous has doubtless misled many into the supposition that exact superelevation is a matter of extreme importance as respects safety. Practical experience of three-quarters of a century on all the railways of the world contradicts this, however, for the superelevation of a curve is fixed for trains of one particular speed only, and for all other trains it must be either too great or too small.

And now, having said plainly that practical railway men have little knowledge of "curve mechanics," and that railway track and rolling stock are everywhere designed according to results of practical experience and not according to theoretical computations, we would say with equal emphasis that greater knowledge of the stresses acting at railway curves is desirable. Certainly every engineer in charge of railway track ought to have a clear understanding of the action of trucks in rounding a curve, and an idea of the nature of the stresses which are set up. The same thing may be said of those responsible for the design of rolling stock. At present, we fear, there are few engineers, either civil or mechanical, who could make a better showing as experts in the science of "curve mechanics" than have the New York Central engineers.

There is this much of excuse to be given: That no text-book in existence fully treats of this subject. The best discussion in print, so far as we know, is that given in Wellington's "Railway Location," but that is incomplete in omitting some of the elements which enter into the matter. The field is one which ought to be covered by a good monograph; but one would search far to find the engineer combining sufficient practical experience with sufficient ability in the analytical discussion of mechanical problems for this purpose.

In what follows we have attempted to point out only some of the elements of the science of "curve mechanics" in the hope that it may make the subject a little clearer in the mind of the average engineer.

When a railway train rounds a curve, there are two main forces which tend to cause its derailment. The first of these, and the most important under all ordinary circumstances, *is the tendency of the wheels to roll in a straight line.* The treads of the two wheels on each axle really form part of a cylindrical surface, and to follow the curve, these wheels must be *slid laterally* on the rail and also slid longitudinally an amount equal to the difference in length of the inner and outer rails. In any rigid truck, this guiding around the curve is done by the flange on the front outer wheel.

The second force which tends to derail the car is caused by the resistance of the trucks to swiveling on the body. At the entrance of every curve, the trucks must be turned on the center-plates and side bearings to an angle with the car body and must be straightened out at the end of each curve. While the resistance to skewing varies very widely, with the condition of center-plates, proportion of weight on side bearings, etc., it is probable that not infrequently the wheel flange is pressed against the rail from this cause all the way around the curve.

These two things, and not centrifugal force, are the chief causes of the flange pressure against the rail, and of the wear of rails and increased train resistance on curves. It is to be particularly noted, too, that these causes are *independent of speed.* The flange pressures and rail wear are greatest on very sharp curves, such as those on the New York elevated railways, where trains run at a speed of only 6 to 10 miles per hour.

In the second place is to be considered the centrifugal force of the cars passing round a curve. This centrifugal force is substantially 58 lbs. per ton on a 1° curve for a body moving at 50 miles per hour; and it varies directly as the degree of curvature and as the square of the speed. The effect of this centrifugal force is first to throw more weight on the outer rail and less on the inner, and second to increase the flange pressure on the outer rail by the amount of the force. By elevating the outer rail, however, a cant inward may be given to the car which will just balance the centrifugal force at a given speed. This centripetal force produced by superelevation is 35 lbs. per ton per inch of superelevation. Thus less than two inches superelevation are needed to just balance a 50-mile an hour speed on a 1° curve. With the centrifugal force thus balanced, there are no flange pressures or tendency to derailment due to centrifugal force.

When the train speed is lower than that to which the superelevation corresponds, the part of the centripetal force which is unbalanced will tend to tip the car toward the inside of the curve and will slightly reduce the lateral flange pressure against the outer rail. On the other hand, when the speed is higher than that corresponding to the superelevation, there will be an outward tipping tendency and lateral pressure.

On ordinary curves, such as are used on main line railways where high speeds are permitted, the excess of centrifugal force is not an important matter compared with the other curve stresses. On sharp curves, however, it sometimes happens that a train will pass over at high speed due to an error, as happened in the Salisbury, England, accident, or from a runaway, as has happened frequently on mountain railways. Under such circumstances, the centrifugal force may, of course, become very great, great enough to tip the train over bodily, as happened at Salisbury.

We have said that a car truck is guided around a curve by the leading outer wheel flange of the truck. This is true whether the truck has four wheels, like the ordinary car truck, or a larger number, like the driving-wheel truck of a locomotive. In the latter case, however, the leading truck of the locomotive aids in guiding the wheels around a curve. The weight of the front end of the locomotive frame is carried by "swing hangers," permitting the truck to deflect to follow the curve and at the same time exert a lateral force upon the engine frame which will vary with the sharpness of the curve.

In considering all these forces above discussed, it must be remembered that they are not static but dynamic, and that there is a large amount of shock, impact and oscillation in the movement of a train around a curve. Well-adjusted transition curves very much relieve the shock at entering and leaving curves at high speeds; but the swaying and jarring which the keen observer will note in the movement of a train on any curved track are evidence of the impacts which are going on.

Further than this, in attempting to compute any of the stresses in wheels, trucks or track, we must remember that all parts receiving these stresses are elastic and yielding. Were this not the case, the impacts above noted would doubtless be much more serious.

Turning now to the stresses which act in the track itself, it may be said at the outset that the chief fastening holding the rails in place, is not the spikes or the rail joints, but *the weight upon the rails.* The rail is held down to the tie by the wheel pressure upon it with a vise-like grip. It is undoubtedly this and this only, that has made sufficient the comparatively weak fastenings of rails to ties which have been in use since the early days of railroading, and which have changed comparatively little while rolling stock has been quadrupled in size and weight.

The recent New York Central and Pennsylvania derailments call attention to the fact that this fastening down of the rail by the weight upon it depends after all on the friction between the rail and its support, and the coefficient of friction between a rail and a steel tie or a steel tie-plate is undoubtedly much less than that between a steel rail and a wooden tie. It is clear that rails on tie-plates or on steel ties ought to be secured by much larger and stronger spikes or clips than have been deemed sufficient with wooden ties. It is probable, too, that forms of tie-plate or steel ties in which the rail is held between shoulders on the plate or tie so that the spikes are not the sole reliance to hold the rails in place will hereafter have preference.

As for the spikes themselves, we have repeatedly urged in these columns the adoption of screw-spikes, such as have been used for many years successfully on European railways in place of the old-fashioned tie-destroying spike which still remains the standard here. If the recent epidemic of serious derailments sets on foot a movement for better rail fastenings, it will have had one compensating result.

It will, of course, be understood that the above is only a mere outline of some of the most important facts in connection with "railway curve mechanics." It is presented here in the hope that it may clarify the ideas of some of our readers who may not have given study to the subject.

LETTERS TO THE EDITOR.

Concerning the Definition of an Engineer.

Sir: I think Mr. Higgins' admirable definition of an "engineer" given in your issue of Feb. 21, 1907, would be greatly strengthened by expanding his phrase ". . . efficiently perform the desired function" into ". . . efficiently and MOST ECONOMICALLY perform," etc.

Mr. Higgins incorporates the question of economy in his comment on what he means by "efficiency," but I don't think the latter word is elastic enough to cover the meaning of economy.

Yours very truly,
Ernest L. Mandel,
Civil Engineering Student, New York University.
New York, Feb. 23, 1907.

Weighing vs. Estimating Steelwork as a Basis for Payment.

Sir: Your editorial in issue of Feb. 14 in relation to the weight of structural steel for which a contractor can reasonably charge is not fair to the contractor who charges for what he furnishes, or to the purchaser who assumes that he gets what he pays for.

The number of first-class structural shops not equipped to weigh their output is very small. One would, I think, be justified in saying that no shop not so equipped is in the first class. Were all the shops using estimated weights, and all on the same basis, there would be no injustice; but with conditions as they are, the actual weight of the finished work is what is wanted, and when the small minority who do not have scales *estimate* the weights on which their bills are to be rendered, they

should get as near as possible to the actual weight of material delivered to the purchaser.

No other material than wide plates will run appreciably over estimated weight. It is quite correct to add a certain excess when figuring the weights of wide plates, but even here the poor downtrodden contractor will often gain a point by ordering his plates by weight per square foot, rather than thickness at edge.

Yours truly, J. C. H.

Comments on the Effect of Stripping the Site of the Fairview Reservoir, Norwich, Conn.

Sir: In view of the interest in reservoir cleaning at this time, and of the letters of Messrs. Manning and Fanning in your issue of Jan. 31, 1907, regarding the Fairview Reservoir at Norwich, Conn., it may be well to note that while there is no evidence that the water has at any time been unhealthful, still, in spite of the thorough cleaning, the common "fishy" odor and taste did exist from time to time, up to 1879, at least. Superintendent Winship's report of that year says:

> Each year, when this unpleasant taste and odor has appeared, it is gradually less each time, and I have never doubted that with proper and intelligent care it may, to a great extent, be avoided.

Since 1879 the water has been remarkably free from bad tastes or odors, but it has had a few short bad spells within a few years.

The lessons of this reservoir, as observed by the writer for more than 30 years, in connection with other reservoirs in the vicinity, are: (1) No amount of cleaning is sure to entirely obviate temporary bad tastes and odors; (2) a well-cleaned reservoir is likely to give reasonable satisfaction; (3) an uncleaned shallow reservoir is pretty sure to give very unsatisfactory water during warm weather.

Yours respectfully,

C. E. Chandler.

Norwich, Conn., Feb. 28, 1907.

Should the Superelevation on Curves Be Increased?

Sir: I notice in your statement describing the terrible accident on the New York Central R. R. on Feb. 16 that the curve at which the train was derailed is "a 3° curve (radius about 1,710 ft.)" and the outside rail "has a superelevation of 4½ ins." The radius of a 3° curve is 1,910 ft. instead of 1,710 ft., but what I should like to get is your opinion on the subject of the proper elevation of the outside rail on curves, more particularly as to whether the outside rail is high enough as a general rule on railroads in New York and New England.

On a recent trip from Boston to Hartford, Conn., I noticed several times when the car struck a curve, and felt it lurch and sway toward the outside of the curve. I have also noticed the same thing on the Boston Elevated Ry. It seems to me that if the outside rail were to be raised an inch or two higher than it is at present on a great many curves that the number of derailments on curves would be decreased.

The table in Searles' "Field Engineering" gives 5⅛ ins. as the proper elevation for the outside rail on a 3° curve with a speed of 50 mi. per hr., and 7⅝ ins. for 60 mi. per hr. I know all trains do not go at such high speed, but should not the outside rail be given the elevation for the highest speed trains? What harm would that do in the case of trains going at a much lower speed?

If the outside rail were placed 8 ins. higher than the inside rail on the standard gage (4 ft. 8½ ins.), the floor of a car would be inclined a trifle more than 8° from the horizontal, but certainly not enough to make the car tip over on the inside of the curve.

As I said before, it seems to me that the outside rail on curves on various railroads could be raised to advantage. I should like to know what others think about the matter.

Very truly yours,

Frank S. Bailey.

27 Commercial St., E. Braintree, Mass.

[The lurching of a car-body when the car enters a curve is almost entirely due to improper easement, and should not be charged to insufficient superelevation.

The question whether a general increase in superelevation would be advisable is not an easy one to answer. Wellington's rule, as stated in his treatise, was to give a superelevation on curves corresponding to the speed of the fastest regular trains up to a maximum of 6 to 8 ins. There are strong reasons against giving any greater superelevation than this. Any train is likely to run at slow speed, and most trains actually do run at much slower speed than the fastest trains. With modern rolling stock with high center of gravity on cars and locomotives, and with heavy wheel loads, one rail raised 8 ins. higher than the other throws a pretty heavy load on the lower rail for safety. It must be remembered that the truck springs yield on the lower side and react on the upper and give the car floor a considerably greater tip than the track. Besides this, when one rail has to take a large share of the load, as it must under such conditions, settlement of this rail is likely to occur at weak spots. Further still, there are many cars which are not loaded centrally; or the load may shift in transit. Take for example a double-track curve around which freight cars of all sorts and conditions, with all sorts of lading must pass, and where a freight wreck toward the inner side of the outer track would foul the inner track on which a passenger train may be passing. It is consideration of these things, doubtless, that causes many railways to fix the maximum limit of superelevation considerably below 8 ins.—Ed.]

Shrinkage of Maps and Errors of Draftsmen's Scales.

Sir: In answer to the inquiry in Engineering News of Jan. 24, on the above subject, the following notes may be of interest: As regards scales I suppose there is no doubt that anything that has celluloid in its make-up is of necessity open to question as to accuracy; even from day to day. I confess, however, that I do not find so very much more difference between some of the "white edged" scales and standard than between scales of different makes. I have an architect's scale (flat) which I got when the white-edged scales were a new thing, some time before April, 1891. I find that scale is now about 0.02-in. shorter in the foot than a steel Brown & Sharp. I used the steel scales of Brown & Sharp for several years (not the brass-nickel plated triangular, but the steel of thin metal which lie on to the paper with an ideal feather edge), but I gave them up on account of the greater ease of reading from wood. The triangular scale I consider an unmitigated nuisance, as being at best hard to read and unless a guard is used (and even then to some extent) making trouble in the way of getting the wrong edge. Of recent years I have used the old flat wood scale with bevel edges. I have usually had them made to order with numbers running from each end; now, however, I have them open divided, both edges alike with a supplementary division at one end with the finer divisions; that is, for a scale of 80 to the inch I have the body of the scale made 12½ ins. long, so as to carry the measurement to 100, and then on the zero end have an additional ¼-in. running towards the end of the scale and subdivided in 10 parts. This makes a great difference in ease of reading as the eye is not tired by the long line of fine divisions. The scale of 100 ft. per in. is 10 ins. long in the body of the graduations so as to stop at 1,000 the same as the 80, and so on. I have always found the celluloid edged scales objectionable from the fact that they are thicker on the edge and hard to read accurately while the wood is as a rule brought to a fairly thin edge. I am told there is one make of celluloid scales that is brought to a feather edge, but have never seen them. Of course such would be easier to read than wood. I always have one or two triangular scales round the office, as sometimes when going out of town it is convenient to take one rather than bother with several flat scales when we don't know what may be wanted. For office use I consider them a nuisance. There can be no doubt that for fine work, 100 to the inch or finer, a diagonal scale is much better and easier for the eyes than any of the others, but it is hard getting them without considerable outlay.

As regards the shrinkage of paper, I have had some little experience with it. My practice is to keep a roll on hand so as to give it plenty of time to season, and then, if possible, to have the sheet exposed to the heat of the office for at least ten days after being cut. From my experience I should say a sheet of 62-in. paper would shrink ¼-in. to possibly ½-in. in process of seasoning. I use mounted "Anvil" for most of my work. It is not, of course, equal to Whatman, but costs less and has the advantage of readily giving almost any size wanted. I use the 62-in. rolls as I do not have use for wider; I have at present an extensive boundary survey in hand and the plan will be on double elephant Whatman. I had the paper ordered over a year ago so as to be sure to be ready, and my surprise may be judged when I found the paper was made in 1853. I wrote my dealers and they wrote the importers, but could get no explanations more than that it must have been in stock at the factory all these years. I have an idea that lot of paper won't make much trouble by shrinkage. I am told by people of wide experience that the great thing is to get paper thoroughly dry and that after that there is comparatively little trouble from change.

Yours truly, O. H. Tripp.

Rockland, Maine, Feb. 27, 1907.

A Method of Taking Topography with an Abney Clinometer Level.

Sir: A method of taking topography which I have not seen mentioned in your columns, is as follows:

The preliminary line is run and levels thereon in the usual way (although the levels need not necessarily precede taking the topography). The topographic party is composed of two men, besides the axeman, their instruments being an Abney Hand Level and a 100-ft. steel tape graduated every foot. The "slopeman" standing at each center stake sends the rodman with one end of the tape out to a point where the slope changes. He (the slopeman) then reads the vertical angle to a point on the rodman the same height above the ground as his eye, and also reads the tape, slope measurement, to the nearest foot. The angle and distance recorded, the slopeman proceeds to the point previously occupied by the rodman, and so on, as far as the topography may be required. In case there is a depression or irregularity which might cause trouble in the office work a sketch will not go amiss. Sections should be taken at all stations and at horizontal angle points of ten degrees or more, also on either side of line in ravines crossing the line, and for a more accurate map the bearings of ravines should be taken with a pocket compass.

HORIZONTAL DISTANCES BETWEEN 5-FT. CONTOURS ON GIVEN SLOPES.

Slope.	Dist.	Slope.	Dist.	Slope.	Dist.	Slope.	Dist.	Slope.	
Deg.	Ft.	Deg.	Ft.	Deg.	Ft.	Deg.	Ft.	Deg.	
½	573.0	10½	27.0	20½	13.4	30½	8.5	40½	5.9
1	286.0	11	25.7	21	13.0	31	8.3	41	5.8
1½	191.0	11½	24.5	21½	12.7	31½	8.2	41½	5.7
2	143.0	12	23.5	22	12.4	32	8.0	42	5.6
2½	114.0	12½	22.5	22½	12.1	32½	7.8	42½	5.5
3	95.0	13	21.6	23	11.8	33	7.7	43	5.4
3½	81.4	13½	20.8	23½	11.5	33½	7.6	43½	5.3
4	71.5	14	20.0	24	11.2	34	7.4	44	5.2
4½	63.5	14½	19.3	24½	11.0	34½	7.3	44½	5.1
5	57.1	15	18.6	25	10.7	35	7.1	45	5.0
5½	52.0	15½	18.0	25½	10.5	35½	7.0	46	4.9
6	47.5	16	17.4	26	10.3	36	6.9	47	4.7
6½	44.0	16½	16.8	26½	10.0	36½	6.8	48	4.5
7	41.0	17	16.3	27	9.8	37	6.6	49	4.4
7½	38.0	17½	15.8	27½	9.6	37½	6.5	50	4.2
8	35.5	18	15.3	28	9.4	38	6.4	55	3.5
8½	33.5	18½	14.9	28½	9.2	38½	6.3	60	2.9
9	31.5	19	14.5	29	9.0	39	6.2	65	2.3
9½	30.0	19½	14.1	29½	8.8	39½	6.1	70	1.8
10	28.3	20	13.7	30	8.7	40	6.0	75	1.3

For the office work in this method two tables are very convenient; an ordinary traverse table with latitude and departure for given angles and distances and a table of horizontal distances between contours on given slopes (shown for a 5-ft. contour interval in the accompanying table). The difference in elevation and distance out to each point is readily taken from the traverse table and then plotted on the map. The process of sketching in contours between these points is greatly facilitated by the other table.

I believe this method to be superior both in speed and accuracy to that of the hand level and cloth tape, especially if the slopes are regular for any distance, in which case the sections can be taken almost as fast as the men can walk from point to point.

The office work is a little more complicated than with the old method, but after one gets the "hang" of it, it is no trouble. I have used this method recently ahead of 50 miles of railway location in the wilds of West Virginia, and it has proved satisfactory. A great deal of the topography was taken by two men only, through the thickest laurel, averaging about a mile a day, taking 200 ft. each side of line. The office work required about the same length of time.

Yours truly,

V. S. Veazey.

Derryhale, Fayette Co., W. Va., Jan. 30, 1907.

Should Concrete be Tamped?

Sir: I would request an opinion from you on the question of concrete, manner of constructing, effects, etc. In your opinion is it not necessary to ram concrete in layers in a structure, either an abutment or pier that is brought above a foundation? What will be the effect of frozen masses where gravel is used instead of broken stone to enter into the mixture, say in masses of 4 to 6 ins. in circumference? Is it not policy at all times and under all circumstances to ram the concrete in layers until the water rises to the surface, in order to make it form a solid mass?

In an abutment that we have recently constructed which was about 30 ft. high, on a pile foundation, a crack has developed where the wing wall joins the main or upright portion of the abutment, commencing at or below the surface of the ground and extending up two-thirds the height of the wall. The concrete in this abutment was not rammed, but thrown in loosely with shovels in course of construction. Now what, in your judgment, is the cause of the crack? The crack is vertical and runs to a point at the top. As a contractor, in laying concrete, I have been required heretofore to ram concrete in layers until the water rose to the surface.

Yours very truly, D. E. W.

Chicago, Feb. 20, 1907.

[There is no definite method of determining the exact relative value of wet and dry concrete by experiment, and on account of it being a matter of observation and experience it has been the subject of numerous discussions between engi-

neers. Ten years ago the idea was almost universally held that concrete should be mixed with just enough water so that when thoroughly tamped and rammed the water would rise to the surface, but now the general opinion is in favor of a so-called "wet" concrete. The exact distinction between a wet and dry concrete is hard to make, but a common assumption is to call a concrete "wet" when it is solid enough so that a man walking on it will sink only to his ankles, but is wet enough so that it will flow along at an angle of about 15° with the horizontal.

In large work, such as foundations and bridge piers, the current practice is toward a concrete laid in layers of from 9 ins. to 2 ft. and wet enough to take the shape of the forms without tamping. In thin walls, fine work and work subjected to special strains, such as an arch ring, comparatively dry concrete well tamped into place is still used. In reinforced-concrete building work, with slabs, columns and beams, wet concrete is always used.

Regarding the failure noted in the above letter, the causes of abutment and retaining wall failure are so many and various that an opinion without investigation would be valueless. If an excessive pressure came on the toe of the abutment, causing a sinking at that point, a crack such as is described would result, provided the stresses so induced were greater than the resisting value of the concrete. It is extremely doubtful if a non-rammed wet concrete would have a lower tensile value than a well-rammed dry concrete, though if the dry mixture is thrown in loosely it is undoubtedly low in tensile strength.

It is generally conceded that no frozen material of any sort should enter into concrete, but with proper precautions for sand and water heating and protection for the finished work there is no reason why concrete work should not be carried on in weather below the nominal freezing point.—Ed.]

Should a Concrete Foreman Be a Competent Designer?

Sir: In your issue of Feb. 7 last, an article appeared on "Common Faults in Reinforced Concrete Design." It seems to me it would have been better had the writer said "Concrete Construction." It is in construction that most of the uncertainties are.

If the designer knew that he was going to have charge of the construction he could with safety cut down the amount of material in the structure. Concrete if put in properly could safely stand greater stresses, but since we have to count on the poorest supervision the amount of material must be increased accordingly. Ofttimes in building a structure the foreman or inspector will allow parts to be built separately where the designer otherwise could count on the shearing strength of the concrete. As a result the designer is compelled to put twice as much strength in that particular detail, hoping that the man in the field will get at least half of it.

There is still another reason why the designer should be in direct touch with the work, and that is in case of oversight in the design. We all make mistakes, and there are sometimes points of weakness not noticeable in the plans until the construction has been actually commenced. Especially is this true when making additions or alterations to structures already in. There may have been changes in the old structure that are not recorded. Alteration may so interfere with the additions as to make them weak or cause them to fail.

If the designer himself cannot superintend the work, I would think it advisable in some cases that he should give instructions as to how the structure should be built; what walls should be built together, or first, etc. To-day it is very seldom that the designer superintends the construction, and the well-executed design goes to the scrap heap just because the man in the field does not know how to put in the structure. How many foremen of concrete work know just why certain bars are placed where they are. In complex structures where continuous-beam action occurs, it is safe to say that the man in charge of the construction hasn't the least idea why steel is placed on both sides of the center of the beam. It is much easier to place concrete if the steel is placed all on one side, and I have seen that done. This to my mind explains many of the failures in concrete. In steel construction each beam is punched for the rivet or bolt that is to go in, and the pieces are not so easily misplaced as the reinforcement in a wall. Too many contractors will take a man off steel or even grading work and put him in charge of concrete work, with the result that the structure has the strength of so much earth.

Many foremen and inspectors think because they put in more concrete than the design calls for they have done a better job. Of course this is not a logical conclusion, though it is very hard to convince them of this. I have in mind a case in bridge construction, of stepped footings, where the contractors dug a footing very much wider than the plans called for. And again, another case where the footings were dug a foot too deep, bringing the reinforcement in the center of the beam.

On many heavily reinforced concrete structures it would pay many times over to get an experienced designer in the field and cut down the factor of safety. Take for example a structure of 500 cu. yds., costing $10,000. If we could be sure of good construction we could with good assurance cut in two the factor of safety in compression. The amount saved would several times pay for the extra expense in salary and a strong structure would be assured.

Again a peculiar case is known to the writer where the superintendent exposed a structure not reinforced for temperature, in excavating for another near by. The exposing occurred in the middle of the winter, and, as the structure had not enough steel reinforcing, it cracked clear through. The man in charge had a set of plans of the reinforcement and knew just how the steel was placed. Yet he knew nothing about the temperature stresses in concrete, but had heard a workman say that he considered the reinforcement very heavy. The result of his lack of knowledge was the failure of an $8,000 structure: a rather costly foreman, indeed.

The logical conclusion seems to me to be that the man in charge of concrete work must be a designer. It is dangerous and costly to do otherwise.

J. C. Holmes, C. E.

712 N. Y. Life Bldg., Omaha, Neb., Feb. 20, 1907.

Water Waste at Buffalo, N. Y.

Sir: In your issue of Feb. 7, 1907, you refer to the "Water-Works Hazards at Washington and Buffalo." In your editorial you say:

> It is almost beyond belief that a city facing such risks as have prevailed at Buffalo for years, should do so little—if anything of moment has been done—to determine the amount of waste, as a preliminary to vigorous measures to suppress it.

The cause of this waste is perfectly well known, and has been for years. We have a large lake, from which the water is pumped, and the people will not realize that it costs anything to pump it, and they cannot understand why, with such a large body of water, there should be any necessity for economy in any way. The common council, realizing that any attempt to stop the waste is unpopular, apparently do not wish to stop it. As far back as 1895, a committee of the common council reported:

> Your committee is informed, however, that a general introduction of meters to equip the water supply of the city would cost in the neighborhood of half a million dollars, and we are of the opinion that that sum would be better devoted to the purpose of increasing the supply.

Any examination of the reports of those in charge of the water bureau will show that annually the bureau has recommended meters as the only solution of the problem. Inspection sounds very well, but with 60,000 taps and 300,000 faucets, it would require 10,000 inspectors to do any adequate work in the line of inspection.

An inspection has, however, gone on continually, and I enclose you herewith a part of the annual report of a year ago, that may be of interest to you in showing that something has been done to attempt to stop the waste, and, I think, all that could be expected. We are certainly as anxious to stop this waste as you or the insurance companies could possibly be.

Respectfully,

Henry L. Lyon,

Deputy Water Commissioner.

Buffalo, N. Y., Feb. 18, 1907.

[We quote from the report for the year ending June 30, 1905, as follows:

> We have not been able to increase the meters as fast as we would have liked because of lack of funds, but we have placed 171 during the year, and now have 1,686 in service. [1,206 taps added during year, making 60,414 in all, of which "about 55,000 are in actual use."—Ed.]
>
> Our continual advocacy of meters is not, I assure you, because it would simplify our work, because it would have the directly opposite effect. But it is the only way to divide the water tax equitably among the users, and our idea is that the Water Bureau should be self-sustaining, not a money-making concern, and that every water user should pay his fair proportion of the expense. It seems to us absurd that a family of two persons should pay as much as a family of ten. There is also no reason why a family should pay five times as much because they have five bath tubs and five closets, so as to make their use more convenient, while they use no more water. It is also absurd that a person should have the best plumbing in his house and always keep it in perfect repair, while his neighbor will have the cheapest plumbing that is continually leaking and which it is necessary to keep water running through day and night to keep it from freezing, and yet both pay the same amounts.
>
> We have continued our work in looking after leaks and wastes, but the per capita [consumption] increases instead of being reduced, and the experience of all water departments is that it can only be effectually reduced by the extensive use of meters.
>
> In connection with this subject we have done quite extensive work with the waste and leak gang during the past year. They do their work at night, when all services are supposed to be closed off. The meter is so connected through hose connecting two hydrants that all water passing into a district will pass through the meter, then the service supplies are all turned off, and if any water passes through the meter it indicates leaks through the main or in the service pipes between the main and service boxes. Where a leak of any account is found it is repaired, then each service is turned on and we can ascertain whether water is running into that property or not. During the day inspection is made and the leaks ordered repaired by the owners. At the end of this annual report I will publish results of some of these inspections in what is mostly dwelling-house districts, and on the smaller and cheaper built houses it shows about 90% of the fixtures leaking, and after repairs in these districts shows a saving of more than 4,000,000 gals. per day. This does not take in the deliberate waste caused by allowing the fixtures to run unnecessarily, which is a much larger amount, and which no system of inspection could reach without the employment of thousands of inspectors.
>
> To install 25,000 meters would cost a large sum of money, but, if the experience of other departments is of any value, the saving of cost in pumping would very much exceed the interest on the investment, and in a few years repay the whole cost. It would have the additional advantage of materially improving the pressure in the water mains and undoubtedly save the city more than the cost of the meters by making unnecessary the laying of a large number of the larger water mains.

[The table relating to waste inspection, mentioned in the foregoing quotation, shows that in 7,795 buildings inspected no less than 7,312 leaking fixtures were found, besides 1,391 "invisible service leaks" and 3,259 "service boxes out of repair."

Mr. Lyon's letter and the quotations which follow it show (see first paragraph of his letter) that something of moment has been done to determine the amount of waste, but no evidence is at hand to indicate that vigorous waste-restrictive measures have yet been taken. The water bureau, we are pleased to say, is alive to the gravity of the situation. The mayor (see Eng. News, Feb. 7) also sees that the time for action has arrived. The common council and the general public of Buffalo will apparently require a water famine and a conflagration to bring them to a realizing sense of the dangers to property and life constantly hanging over the city; the dangers to life, as we pointed out in our issue of Feb. 7, are due to the impurity of the supply, as well as to the fire risk. Any one can see that a per capita water consumption of 350 gals. per day, with prospects of an increase, is not conducive of the speedy adoption of water filtration.—Ed.]

Concerning Unit-Stresses and Other Points in Reinforced Concrete Work.

Sir: The Engineering News in its issue of January 17 published a letter by the writer, criticizing what he understood to be the position of the editor regarding unit-stresses on concrete. In your issue of February 7, this letter has been misquoted by Mr. W. J. Douglas. This misquotation, as well as the nature of the criticism, apparently misunderstood by the editor, requires some comment.

The discussion of reinforced concrete failures by some editors, engineers, contractors and workmen, which the writer has read and heard, to fix responsibility therefor, reminds him somewhat of the story told him by a mining engineer friend of his concerning the collapse of a wooden ore bin. There were several bosses around the plant, each having charge of a separate department or class of work, and each apparently having a finger in the construction of this bin. He went to each in turn and was referred to the next man as probable possessor of information concerning the construction and the cause of collapse; and the final conclusion was that none of them knew anything about the bin but each thought the next man responsible. Thus the editor, in blaming the contractor, has very likely failed to call his subscriber's attention to the unreliable character of the agents representing some of the reinforcing material which his paper is advertising, and perhaps is not without his share of more or less indirect responsibility for the difficulty, although the paper is not to blame for

advertising any class of material, which, regardless of question of cost, if used in sufficient quantity and with reasonable judgment, may produce a safe structure. The contractor, on his part, blames the engineering paper and editor because he has run into the difficulty in using a material advertised by the engineering journal. The engineer gets out of his responsibility in a very smooth manner. He brings forward an expert professional brother who advises the owner and the public in general that the failure was due to the premature removal of the forms or to faulty work on the part of the workmen; and the report may not be without some foundation, since an inferior or questionable design may, with sufficiently considerate care, leaving the centering in ninety days (the time it took the firm of Butler Bros., Contractors, of this State, to put up a ten-story reinforced concrete building in the middle of a Minnesota winter and get the centering out) be able to stand for the purpose intended and give fairly satisfactory service, with some degree of safety, as the cement hardens up. As to the workman, as a rule, he does not talk back; if he did, he would be likely to express some pertinent opinions regarding the engineer, whose specifications may have required more than ordinary care in placing the concrete to get satisfactory work, through improper proportions of the coarse and fine aggregate and more than a reasonable time before removal of the forms, due to failure to properly tie the construction together. Leaving the forms in more than the average period would necessitate use, by the foreman in charge, of more than a reasonable amount of lumber for centering, running the cost of the execution of the work up, with a consequent bad record for himself with his employer, who figures his efficiency in proportion to the profits accruing from the work.

The writer has observed in general that those who talk the most about the necessity of inspection are generally those who fail to specify a brand of concrete that does not require more than ordinary care in properly placing it, and are themselves largely responsible for this necessity, when dealing with a fairly honest and well-meaning contractor.

The object of the writer's previous letter seems to have been attained first, in the statement of the editor that he did not advise limiting the working stresses on concrete to the ridiculously low figure on good concrete of 300 lbs. per sq. in., and the frank admission of Mr. Douglas that he agrees with the writer that no engineer is safe who suggests a uniform value for the working stresses without taking into consideration the type of reinforcement. The writer will add another suggestion which he thinks Mr. Douglas will also agree to, and that is that no engineer can be regarded as safe unless he takes into consideration not only the character of the reinforcement but the character and size of the aggregate and the ratio of sand which enters into this concrete, in specifying his maximum working stress.

Had Mr. Douglas seriously read through the letter which he criticizes in your issue of February 7, he would have noted first that the writer quoted what was allowable under the French rules for proportioning concrete, and that the reason for the limitation of the maximum stress to three-fifths of the compressive strength of 8-in. cubes, 90 days old, where the columns are properly hooped, is not a question of safety of the work, but rather a question of proper protection of the steel, leaving a reasonable margin between the working value of the concrete and the value at which the concrete is found to check outside of the hooping and expose the metal. He would note further that so far from recommending 3,000 lbs. per sq. in. in general as a maximum, the writer states in the letter referred to that such a value would require a degree of lateral reinforcement not warranted from the economic standpoint in most cases.

Mr. Douglas is to be credited with the contribution to the Engineering News of a paper presenting many practical points of value; still his recommendation of a 1:2:5 mixture for such work would seem to be applicable more to mass concrete than to reinforced skeleton structures. On the basis of such proportions, the writer would not be inclined to advocate a higher working stress than that mentioned by Mr. Douglas, except in the case of suitably hooped columns, and he would, in general, refrain from using such a mixture on the ground that there would not be a sufficient excess of fine material for an engineer to be warranted in expecting sound work by the exercise of ordinary care on the part of the workmen.

Mr. E. Lee Heidenreich, in the "Engineering World" of February 1, calls attention to the condition in building ordinances, New York City allowing 500 lbs. per sq. in. in reinforced columns; Brooklyn permitting 1,000 lbs. per sq. in., although under different conditions as to percentages of reinforcement, while Considere loads his heaviest columns with 1,653 lbs. per sq. in. (See Beton & Eisen, December, 1906, p. 298.)

Now, the term concrete covers more different grades of material than does the term timber, the latter ranging, even among the hardwood varieties, from the brash hardwood timber, cut long after passing its prime, which will break under any unusual load or shock, to the toughest white oak, which, when cut in its prime and properly seasoned, will enable one to tie a knot in a $^3/_{32}$-in. strip without breaking it. So with concrete. We have on the one hand the inferior and unreliable mixtures in which there are voids through lack of sufficient fine material to fill the voids between the coarser aggregate, with corresponding difficulty in properly placing the mixture and lack of strength and ability to endure rough usage (such as vibratory stresses), and on the other hand the richer mixtures which are properly proportioned with an excess of at least 20 to 25% more fine material than is required to fill the voids between the coarse aggregate, and possessing corresponding ability to withstand vibration and jar of machinery, such as beaters in paper mill floors and similar trying service, without injury.

As Mr. Douglas admits that common sense is a requisite for the attainment of proper design, so also he will agree with the writer that it is a requisite in deciding upon a suitable working stress for any given case, and the writer is not willing to pass judgment upon any particular case without examination of the materials, what the concrete is made of, the design of the reinforcement and the service expected of it, much less recommending a general maximum for universal use.

The writer has no prejudice against deformed bars or special types of reinforcement, and is ready to credit the patentees of some of these with their just due, as pioneers in the promotion and introduction of reinforced concrete. Some of these bars are recommended by the writer for use in concrete work placed under water where we cannot count on the shrinkage of the concrete and the development of the elastic grip of the concrete on the reinforcement, due to this shrinkage, which we would get where the concrete hardens in the air, and where it is not reduced by subsequent submersion. As in bridge work, the writer would not recommend material which has been cold-worked, torn rough or sheared; he does not approve of it for reinforced concrete. His experience has failed to show any advantage whatever to be gained by the use of deformed bars under vibratory stresses and shock of machinery where the mixture of concrete has been properly specified and is suitable for such service.

In his remarks as to the strength of slabs, Mr. Douglas appears to place considerable stress on arch action. In moderate panels, say 16 to 20 ft., the limited amount of test data of which the writer has record (between one hundred and two hundred tests), does not appear to bear out his statements for full panel tests, and it will be interesting to know what test Mr. Douglas has made, what the different deflections were, both in wall and interior panels, and what the character of failure was, the writer, for example, having seen a slab over 20 ft. square, loaded until the deflection was approximately 10 ins., where the concrete cracked in places so you could put a rule through it, still carrying the full load causing this deflection, and requiring a considerable addition to the said load to produce rupture. He has further observed no appreciable difference in deflection between wall and interior panels under a full panel test.

The writer is further of the opinion that if the work is properly reinforced, a *sudden* collapse will never occur after the concrete has had reasonable time to set. We have records, of course, of such collapse in combinations of tile and concrete, reinforced with insufficient lap of the bars, but the writer has yet to see a case of such collapse where the engineer has properly done his work in reinforced concrete and a proper mixture of concrete has been used.

In conclusion, the writer does not hesitate to express his opinion that if engineers in general would specify a better concrete, and use a correspondingly smaller amount of it, they would get more reliable work and could use higher working stress with a greater and more uniform factor of safety. He is, further, of the opinion that the work of M. Considere, in which he has used 1,653 lbs. per sq. in. in compression on his columns, would develop, if tested to destruction, a greater factor of safety than many American designs he has seen where the working stress is under 400 lbs. per sq. in.

Very respectfully yours,

C. A. P. Turner.

Phoenix Bldg., Minneapolis, Minn., Feb. 14, 1907.

Notes and Queries.

The following corrections should be noted in the table accompanying Prof. Wm. Kent's article on "The Carrying Capacity of Pipes in Low-Pressure Steam Heating," in Engineering News for Jan. 31, 1907, foot of p. 142.

For ¾-in. pipe under pressure of 3.3 lbs. by gage read .175 lbs. per min. instead of .375.
For 2-in. pipe under pressure of 3.3 lbs. by gage read 2.194 lbs. per min. instead of 2.191.
For 12-in. pipe under pressure of 10.3 lbs. by gage read 245.0 lbs. per min. instead of 145.0.

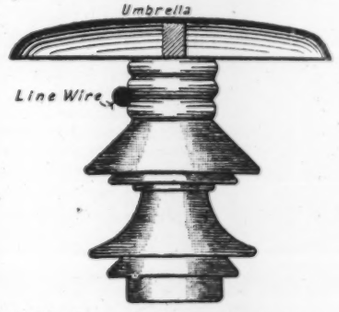
RECENT PRACTICE IN ELECTRICAL TRANSMIS... POWER.*

By W. B. ESSON,† M. Inst. C. E.

Recent progress in electrical transmission of p... been chiefly in the direction of raising the pre... the overhead lines and in devising means whe... could be successfully accomplished. Pressures ... 10,000 to 20,000 volts are now quite common. ... installations have been designed for 60,000 v... have worked successfully at their rated ... Though the majority of the latter undertakings ... yet sufficiently loaded to make the full-rated ... necessary for regular working, they are gradual... ing that condition, and in several projects in ... probability of being able to work some day a... volts is being kept in mind. In South Africa it ... posed to use transmission at 150,000 volts ... Victoria Falls and the Rand.

A line pressure equal to 1,000 volts per mile of ... mission has been considered good practice; but ... subject to certain limitations. In the first plac... not worth while ever having a less pressure than ... volts, except for the smaller installations. Agai... highest pressures of which we have any experi... a commercial scale are from 50,000 to 60,000 vol... as yet we cannot go beyond these even for distan... of 200 miles or more.

Experience shows that there is no difficulty in w... armatures of three-phase machines of moderate si... for line pressures of 15,000 volts. Though many large un... dertakings, including those in northern Italy, are w... ing at line pressures such as permit the armature... to



An Umbrella Type of Insulator for the Prevention of Arcing with High Pressures under Rain Conditions.

be connected directly with the lines, it should be noted that, with the exception of the Valtellina Railway, 15,000 volts is nowhere exceeded. It may be stated as a general rule that this constitutes the limit of line pressure to which we should go without using step-up transformers.

The insulators have always formed the weak points in the line, and the risks incidental to very high voltages have been reduced as the weak places have been made fewer. By the adoption of steel poles for modern lines instead of wooden ones it has been possible greatly to increase the length of the spans, and, as a consequence, diminish the number of insulators. Whereas the usual spacing for wooden poles is forty to the mile, steel lattice poles may be spaced twelve to the mile, with the result that in the latter case less than one-third of the insulators are, required. In Italy, some of the spans between steel poles measure 920 ft.

A special pole used for crossing flat country has been designed on the principle that in a straight level line with equal spans, the only stress to be borne by the line is due to wind pressure, and hence it is unnecessary to employ poles equally stiff in all directions. This pole accordingly presents great resistance in the direction of the wind, i. e., at right angles to the line, but low resistance in the direction of the line. It is elastic, and can deflect over 16 ins. in the latter direction without exceeding the limit of elasticity, the consequence being that, in the case of a wire breaking, the poles nearest the break will bend over somewhat, thus relieving the load on the spans and preventing damage being done to the line as a whole.

The only novelty of note in insulators which has appeared recently is that shown in the accompanying illustration, and is due to Signor Semenza, who has had large experience with the power lines in Italy. In rainy weather, the dome or outside petticoat of an insulator to which the wire is attached, becomes wet to its edge. Accordingly, for the time being the dome becomes a conductor, and may be considered as an expansion of the line wire equal to the dome's external surface. When tested for arcing distance with high pressure under rain conditions, sparks will be visible in the form of streamers all over the surface, from the bind...

*Condensed from an article in The Engineer, of Lond...
†1 Victoria Street, S. W., London, England.

the edge of the dome, and the consequence is a rainstorm an insulator is only good for about ... of the pressure which it will stand dry. To this state of things Signor Semenza has hit simple expedient of putting an umbrella over ...tor.

...brella consists of a plate of insulating material, ... shown, made sufficiently large to keep the ... and let the water run off well clear of its ... is claimed that the cost of insulators will be ...40% if this device fulfils the promise of the ...inary tests, on ac... the insulators be... much smaller. Tests ...hown that an insu... fitted with the um... will stand in a heavy ...ouf before arcing ...40% of what it will ... dry, or giving the ...figures of a test, the ... pressure in a shower ...111,000 volts against ... volts dry. In... have to be in... large enough to ... the requirements of service in foul weather, and ... ordinary type of insulator for 50,000 volts should ...bout 10 ins. in diameter. It has to be of this ... because the insulation falls off so much in rainy ...ther; but, obviously, if means can be devised to ...nt this falling off, very much smaller insulators ... be used. Signor Semenza finds that a 6-in. insulator, ...d with a 12-in. diameter umbrella, gives as good ...ation as the ordinary 10-in. insulator, while the ...brella only costs a few pence. It must be admitted, ...course, that this device is as yet on its probation. ...localities where the cleansing effect of rain on the ...insulators is relied upon to keep the line in serviceable ...condition, the umbrella would not find a welcome. But ...such localities are not numerous, and power engineers ...will await with interest the results from the invention ...tested on a working line.

Transformers for pressures up to 25,000 volts are about equally divided between air-insulated and oil-insulated classes. Above this pressure the oil-insulated class predominates.

In the general design of the power-house everything is arranged with a view to reducing labor to a minimum. This applies to both steam and water plants, though in the latter the labor is, in any case, comparatively small. In every steam power-house of any size, coal and ash-conveying equipments are indispensable, while to secure low capital cost, and avoid complication in the switch gear, the generating units are of such size that there are not more than eight to ten altogether when the equipment is complete. This applies to water power plants as well, though in their case the head available has considerable influence in determining the number of units.

WEDGE TYPES OF RAIL FASTENINGS FOR USE WITH STEEL TIES.

The type of rail fastening most commonly employed in connection with steel ties is a combination of bolts and rail clamps or clips, and this type of fastening has in general proved very satisfactory in service, both in regard to security and to maintenance. The bolts require little attention and show little tendency to become loose, when once brought to a full bearing, although when first applied they have usually to be tightened two or three times. This has been the experience abroad, and so far as we are informed it has been the same in this country. Another type of fastening which is used to a limited extent abroad, is an adaptation of the screw spike for wooden ties, a short screw being threaded into a plate secured on the inside of the tie, while the head of the screw bears directly upon the edge of the rail base. This latter system appears to be less satisfactory than the other, and in the "Bulletin" of the International Railway Congress for January, 1907, Mr. L. Schlussel, of Paris, France, presents a mathematical analysis of the causes which tend to cause the working loose of screws when used as rail fastenings.

His proposed remedy is to use clamps instead of screws, and while this type of fastening was employed in some of the earliest designs of track construction with steel ties, Mr. Schlussel's application is novel. The general arrangement is shown in Fig. 1, and it will be seen that there is a single clamp on each side of the rail, inserted in an oblong hole and then turned round so that its upper and lower projections bear upon the inside of the tie and the top of the rail flange. The projection at the back keeps the clamp from slipping through the hole while being applied. The pressure or grip of the clamps is set up by means of a wedge-shaped tie-plate beneath the rail. Presumably this is the ordinary European tie-plate, having an inclined face to give an inward inclination to the rail (conforming to the coned tread of the wheels), but instead of being mechanically attached or locked to the tie it is held simply by the friction due to its being driven in so as to set up the pressure between the clamp, the rail and the tie. The function of the wedge plate is to produce this pressure, while the function of the clamp is to maintain the pressure necessary to secure the rail firmly in place.

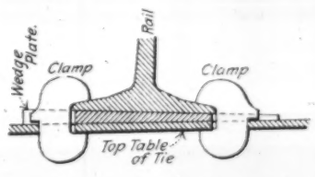


Fig. 1. Proposed Wedge-Clamp Rail Fastening for Steel Ties.
L. Schlussel, Paris, France; Inventor.

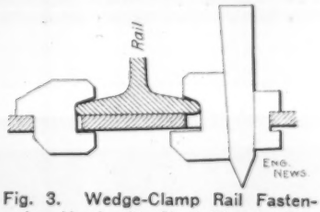


Fig. 3. Wedge-Clamp Rail Fastening Used with Steel Ties in Germany.

In this connection we have received a letter from Mr. Albert J. Himes, M. Am. Soc. C. E., Assistant Chief Engineer of the New York, Chicago & St. Louis Ry., at Cleveland, O., commenting upon the Schlussel system and describing another form of wedged-clamp fastening designed by him some years ago. It embodies the same principles, and the main difference is that in order to produce the pressure it employs (instead of the wedge-plate under the rail) a horizontal lip or projection on the upper end of the clamp which will be distorted when forced upward on the rail base, as at X-Y in Fig. 2. The clamp is secured in position by a vertical key inserted in the same hole in the tie. Mr. Himes suggests that much study will be required to perfect a fastening that will be to track with steel ties what the spike has been to track with wooden ties, and he considers that some fastening of the sort proposed by him would be found much more economical and satisfactory for use with steel ties than the threaded bolts with washers and nuts which are now being used. One objection that appears evident, however, is the possibility of causing cracks at the holes in the ties, due to the strain and shock incident to the distortion of the clamp when being tightened upon the rail. However, experience alone can prove or disprove the merits in a case of this kind.

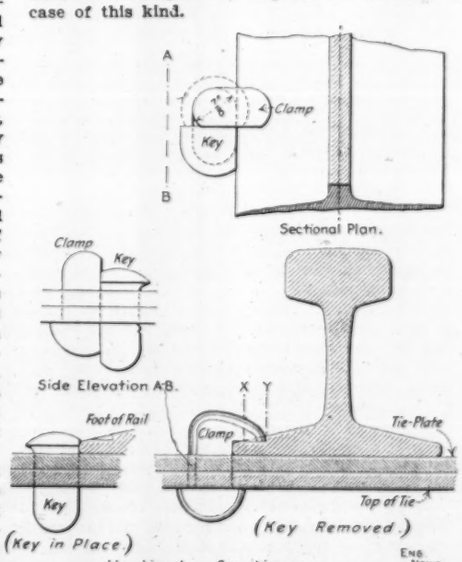


Fig. 2. Proposed Wedge-Clamp Rail Fastening for Steel Ties.
Albert J. Himes, Cleveland, O., Inventor.

As already noted, the wedge and clamp system of fastening has been used with steel ties from a very early date, and in Fig. 3 is shown a fastening of this kind which dates from 1867 and was at one time extensively employed in Germany and elsewhere. The clamps are somewhat similar to those of Mr. Schlussel, but with the back vertical, forming the bearing for a vertical gib or taper key. In the original design, the key was simply driven between the rail clamp and the metal of the tie, but the keys would work loose, causing considerable noise from the rattling of the parts, while the driving of the key and the vibration and shock under traffic frequently resulted in starting cracks in the tie at the holes for the fastenings. An additional clamp was therefore used, as shown, to give a larger bearing to the back of the key and also to relieve the metal at the hole from the direct action of the key. As thus modified it was found to give satisfaction and was used for 25 years and more, but the wedge type of fastening has now given place very largely to the bolted clamp type. It will be seen that each fastening consisted of four parts, as compared with three in Mr. Schlussel's proposed design. The adjustment of gage was effected by using clamps of varying widths.

Another fastening of the wedge type which has been very extensively used abroad within recent years, more especially in India, consists of a horizontal key wedge fitted between the edge of the rail base and a projection on the tie. The key is grooved to bear on the top and side of the rail base, and is driven longitudinally with the rail. The projection against which it bears is either stamped out from the face of the tie, or is a separate piece; in the latter case it may be either riveted in place or loosely fitted to a hole in the tie.

MULE HAULAGE AND ELECTRIC HAULAGE FOR MINES.*

By M. F. PELTIER.†

The introduction of the electric haulage system in the mine noted below has not only resulted in reducing the cost of production, but has also made practical the development of more extended operations, and increased the output from 1,400 tons to a daily average of 2,000 tons. The motors have pulled as much as 2,570 tons in eight hours. The plant was installed at No. 3 mine of the Peabody Coal Co., Marion, Ill. The seam is 9 ft. thick, of which 2 ft. is left for roof owing to the soft nature of the sandstone immediately over the coal.

Prior to installing electric haulage, there were 16 gathering mules and 17 mules working in spike teams, pulling from the lyes to the bottom, producing 1,400 tons of coal. Owing to size of cars, grade and average haul of 1,800 ft. from lyes to bottom of shaft, the output had reached its limits with mule haulage, so after careful examination of the existing conditions, it was finally decided to install electrical haulage. Two 15-ton Goodman electric locomotives with double-end controller were installed. The frame of the locomotive consists of an upper and lower casting securely bolted together, and suspended from the wheel axles. No part of this frame overhangs the rail, which is an important factor in narrow entries. The trolley pole is of the reversible type, and so designed that it accommodates itself readily to the maximum and minimum height of roof. The trolley wire is securely fastened to the roof with trolley hangers, 8 ins. outside of the outer rail. The wheels have steel tires, which, it is claimed, gives them a tractive effort of 20% above chilled-rib wheels. Each locomotive is provided with two motors wound for 250 volts, and exerts a draw-bar pull of 8,200 lbs. on the level. They have pulled 17 loaded cars up a 2½° grade, 1,200 ft. long. The cars weigh when empty 1,950 lbs., and hold on an average of 6,600 lbs. of coal, so that the weight of loaded trip would be over 72 tons.

The track gage is 42 ins. The track is laid with 40-lb. tee rails, bonded and cross bonded for the return current, and laid on good white oak ties. There are 9,000 ft. of track. The curves on the locomotive haulage track are 40 to 60 ft. radius, which gives 16 ft. to 18 ft. from point of frog to point of switch on all cross-overs and turnouts. The curves are elevated on the outer rail to suit a speed of eight to ten miles per hour. Therefore, when a trip is started it will not lose speed or coal until it reaches the bottom. The coal is all caged on one side, and the empty cars are taken off on the other side. The electrical power for operating the motors in the mine is supplied by a 175-KW. generator belted to a 200-HP. engine

*Abstract of a paper read at the annual convention of the Illinois Society of Engineers and Surveyors at Peoria, Ill., Jan. 23, 25. An article on the same subject appeared in our issue of Jan. 3, 1907.

†Mining Engineer, Peabody Coal Co., Marion, Ill.

in the power-house department of the building containing the hoisting engines. The generator also furnishes light for the underground haulage ways. This generator is designed and built to meet the special requirements of mine service where constant and extreme variations in load are the rule. From the switchboard in the power-house the current is transmitted over a lead cable running down the manway and to the main haulage way of the mine.

The machinery making up the electrical installation is as follows:

2 locomotives, at $2,300	$4,600.00
Generator and switchboard	2,400.00
Engine, 18 x 18 ins., 200 HP.	2,000.00
Foundations and placing engine and generator.	300.00
2 tubular boilers, 150 HP., complete	2,800.00
9,000 ft. of trolley wire	1,019.90
200 ft. of lead cable, at 55 cts.	110.00
665 trolley hangers, at 65 cts.	432.25
768 bonds, at 35 cts.	268.80
75 cross bonds, at 35 cts.	26.25
18 interchangeable trolley frogs, at $2.75	49.50
1 extra 250-volt armature	375.00
2 motor jacks, at $12.80	25.60
Extra fittings for motors	86.24
115½ tons 40-lb. rail, at $28.25, $3,291.13 (credit for 25-lb. rails, $2,056.75)	1,234.38
6,055 white oak ties, at 10 cts.	605.50
65 kegs spikes, at $3.75	244.50
22 split switches, material and labor, at $17	374.00
Fishplates and bolts	280.00
Lumber for trolley supports	76.11
Sundries	54.55
Entire labor cost	3,810.21
Total of complete installation	$21,172.79

Mules: Average cost, $225; depreciation, 20%; interest, 6%.

Cost per mule, divided for 275 work days, per work day.

Depreciation	0.163
Interest	0.049
Feed	0.200
Shoeing and stableman	0.158
Total per day, 275 day basis	0.57

Team haulage, daily average, 1,400 tons.

17 mules, at $0.57 .... $9.69
9 drivers, at $2.56 ..... 24.24 Team drivers 15 cts. extra, or $1.20 extra for 8.
Total $33.93

Cost per ton outside, mule haulage, $0.024.

Cost of operating electrically, 275 work days.

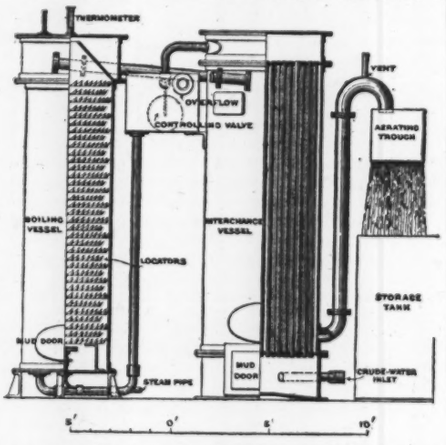
2 locomotive runners, at $3.20	$6.40
2 trip riders, at $2.56	5.12
¼ electrician, at $75.00 per m	1.08
¼ fireman, at $2.02	0.67
Fuel, 57 tons, at 75 cts.	3.75
Total fixed labor, etc.	$17.02
Interest on investment, $21,172.79, at 6%.	$4.62
Depreciation and repairs, $21,172.79, at 8%.	6.16
Oil and waste	.30
Taxes	.50
Total	$11.58
Total daily operating cost electrically	$28.60
Cost per ton, based on 2,000 tons	$0.014

It will be seen from the foregoing that the electric haulage plant besides increasing the output and saving 1 ct. per ton (which means $20 per day), practically pays for itself in four years.

WATER STERILIZING AND SOFTENING PLANT FOR THE LEAVESDEN ASYLUM, ENGLAND.

A water sterilization and softening plant for the Leavesden Asylum in Hertfordshire, England, has been in successful operation for a year or more. The water is taken from a well in the chalk, 225 ft. deep. The records of the asylum having shown an abnormally high death rate from diarrhea, and an investigation also indicating that the well water was subject to surface contamination, it was concluded to install the plant briefly described below. The sterilization and softening are accomplished by boiling the water by steam, the precipitated salts being deposited on trays. The plant is in three units of equal size, having a combined capacity of 10,800 U. S. gals. per hr., or about 260,000 U. S. gals. per day. The fuel cost of sterilizing the water, with coal at 17s. 1d. ($4.15) per long ton, is stated to be not over 1½d. per 1,000 imperial gals. (2½ cts. per 1,000 U. S. gals.). The plant was installed by the Lawrence Patent Water-Softening & Sterilizing Co., with the understanding that the hardness of the water should be reduced from 19° to 9°, Clark scale, and that the difference in temperature between the incoming and outgoing water should not exceed 20° F. Each of the three units, according to a paper by William Thomas Hatch, M. Inst. C. E. (Excerpt Proc. Inst. C. E., Vol. CLXVI., 1905-06, Part IV.),

consists of a heat-interchange vessel, similar in form to a surface-condenser, 5 ft. 10 ins. in internal diameter by 9 ft. 6 ins. in height between the tube-plates, and containing 580 solid-drawn copper tubes, 2 ins. in diameter, expanded into brass tube-plates; and a boiling vessel of mild steel plate, the upper part holding perforated trays on which a considerable portion of the scale is deposited, and the lower part forming a mud-chamber. Two of the boiling vessels at Leavesden have square tops and bottoms, the central part being cylindrical; the third vessel is cylindrical throughout. In the center of the boiling vessel a galvanized inner cylinder is fixed, containing the "locator"-plates, upon which the carbonates are deposited in solid form. The action of the apparatus is as follows: The water-supply, taken from a large overhead tank, first passes through an automatic valve controlled by a steam-piston, so regulated that should the steam-pressure fail, from any cause, the whole water-supply is immediately shut off; the water is then led into the bottom boxes of the interchange-vessels, and, slowly rising through the tubes, attains a temperature of about 190° F. by taking up the heat from the return-water outside the tubes. It then passes over from the top box through the cover of the boiling-vessel, falling first over the trays, which are above the water-level. These trays are of mild steel, and are bolted together in groups for easy removal, the edges being "finned" in order to break up the flow of water. Large trays having a hole in the center alternate with smaller trays having no hole, thus dividing the ebullition-cylinder into a number of chambers and presenting as large a surface as possible for the collection of deposit from the water while it is boiling. Steam is taken in through the bottom of the boiling-vessels and discharges between a pair of flanges in a horizontal direction, rising upwards against the downward flow of water and escaping to atmosphere, if



Improved Form of Lawrence Water Sterilizer and Softener.

not condensed, through vent-pipes in the covers of the boiling-vessels. The boiled water, having reached the bottom of the ebullition-chamber, rises in the annular space between the two cylinders and passes out by the return-pipe into the heat-interchange vessel just below the top tube-plate. Descending slowly outside the copper tubes, it parts with its heat and leaves by an outlet-connection just above the bottom tube-plate on the opposite side. The three outlet-pipes are taken to one collecting-pipe, which is carried to the proper level to keep the interchange-vessels full of water, and there discharges into a teakwood aerating-trough in the open air, having a copper bottom perforated with fine holes, the size and number of which are so adjusted as to give the "critical head" to ensure fine streams descending individually, without mingling, into the tank below; this results in a most satisfactory re-aeration of the sterilized water. The water is then pumped up into the main storage-tank in the water-tower, whence it flows by gravity to all parts of the asylum.

In a later type of plant, some changes in detail have been made. The accompanying illustration will serve to give a general idea, in connection with the matter quoted above, of both the plant installed at Leavesden and the improved type. In the latter, the automatic valve is omitted and the water is taken into the bottom box in two places instead of one, in order to give better distribution to the tubes. The distance between the tube-plates is increased by 6 ins., making a total of 10 ft.; and where 2-in. tubes are used, the number of tubes is 600. Provision is made for inserting a hose pipe for washing out any soft scale that accumulates on the tubes. The boiling-vessel in the new type of plant is 2 ft. 11 ins. internal diameter and 10 ft. high, and the locator-plates fill the whole vessel, thus doubling the depositing surface as compared with the Leavesden plant. The discharge box of the boiling-vessel has a movable cone with an opening in the top. The normal water level is 4 ins. above the top of the cone, and no water can pass out of the ves... till boiling begins, nor can any water be di...ed that has not been actually boiled. The ... of discharge of water through the boiling ... in the new type is given as 10 minutes; ... the Leavesden plant, tests indicate that ... the passage of water through the whole ap...tus, 45 minutes is required. The monthly ...ra-ture records at the Leavesden plant fr... Oc-tober, 1904, to September, 1905, sh... an average of from 52° to 54° for the ...ing water and 71° to 76° for the outgoing ...eri-lized water, month by month. The di...nce between the incoming and outgoing wat... ...ged from 19° to 23°, and showed a crude ...age of 21.

A number of tests were made in con...tion with the installation of the Leavesden ...lant. Among the results shown by these, the f...ing may be noted: Flattened tubes 2 ins. in di...eter seemed to give the best results, but "the me-chanical difficulties attending the use of el...tical tubes led to the final adoption of a round tube 2 ins. in diameter"; spiral showed no adv...tage over straight tubes; the amount of heat ...ter-changed was found to be almost directly pro-portional to the interchange surface.

THE KINETIC ENERGY OF FLOWING WATER.

By L. F. HARZA.*

It frequently becomes necessary in careful hydraulic experiments to consider the kinetic energy contained in streams of flowing water. It seems to be a universal rule in such cases, so far as the writer is aware, to consider that the kinetic energy of the stream is expressed by the well known formula

$$E = \frac{W v_m^2}{2g} = \frac{w a v_m^3}{2g}$$

where W = weight of water passing any cross-section, in pounds per second.

v_m = average velocity of the water throughout the cross-section, in feet per second, equal to the discharge in cubic feet per second divided by the cross-section of the stream in square feet.

w = weight of a cubic foot of water, in pounds.

a = area of cross-section of the stream, in square feet.

g = acceleration of gravity.

E = energy in foot-pounds per second.

This formula is strictly correct only for a stream which has uniform velocity over all parts of a cross-section. Such streams do not occur; in all actual cases of flowing water there is a considerable variation of velocity over the cross-section. Water flowing in a pipe, for instance, has a greater velocity at the center than at the outer boundary of the stream. A stream in an open channel has a minimum velocity at the bottom, and a maximum near the upper portion of the depth. The true energy of a stream is the summation of the results obtained by applying the above formula to each elementary portion of the cross-section, or

$$E = \Sigma \frac{w a v^3}{2g} = \frac{w a}{2g} \Sigma v^3$$

It can be shown mathematically that

$$\frac{1}{n}\left(v_1^3 + v_2^3 + v_3^3 + \ldots\ldots\ldots v_n^3\right)$$

is always greater than

$$\left(\frac{v_1 + v_2 + v_3 + \ldots\ldots\ldots v_n}{n}\right)^3$$

and therefore the true energy in any stream is greater than that obtained in the ordinary way, no matter what the law of variation of velocity in different portions of the cross-section.

If the distribution of velocity is known in any case there is no reason why one should not apply the energy equation to small portions of the area and then add the results in a way similar to that used in obtaining the discharge of the river. In some experiments now under progress in the hydraulic laboratory in the University of Wisconsin, the actual total energy of flowing

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water in a pipe is desired, and the writer has made the following mathematical investigation to determine about what degree of dependence can be placed on the value of the energy as determined in the ordinary way, and whether more exact methods are worth while.

The investigation requires a knowledge of the mathematical law of distribution of velocities over the cross-section. This law for pipes of 24, 30 and 42 ins. in diameter and with velocities ranging from .5 to 7.5 ft. per sec., was quite well determined by Williams, Hubbell, and Fenkell in 1899. They found that the average velocity is about 0.84 of the velocity in the center of the pipe, and that the curve of velocity from the center of the pipe outward to the surface agrees more nearly with an ellipse than with a parabola.

Assuming the accuracy of these results, let

v_s = velocity of water along interior surface of pipe.
v_c = central velocity.
v_m = mean velocity.
v_y = velocity at distance y from the center line of pipe.
r = radius of pipe.
W' = weight of water passing any element of the cross-section in one second.
w = weight of a cubic unit of water.
E = energy of the stream.

Then, with reference to the accompanying sketch,

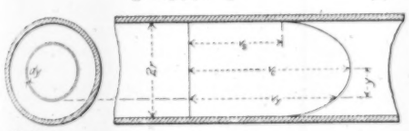
$$W' = 2\pi w v_y y\,dy$$

$$dE = \frac{W' v_y^2}{2g} = \frac{\pi w v_y^3 y\,dy}{g} \qquad (1)$$

First assume the paraboloidal distribution of velocity. From known properties of the parabola,

$$v_y = v_s - \frac{(v_c - v_s)\,y^2}{r^2}$$

$$v_m = \tfrac{1}{2}(v_c + v_s) \qquad (2)$$



Substituting the formula for v_y in Eq. (1) and integrating between the limits $y = r$ and $y = 0$, gives:

$$E = \frac{\pi w r^2}{g}\left[\tfrac{1}{2}v_s^2 - \tfrac{1}{4}v_s^2(v_c - v_s) + \tfrac{1}{6}v_c(v_c - v_s)^2 - \tfrac{1}{8}(v_c - v_s)^3\right]$$

Assuming the ellipsoidal variation of velocity will give

$$v_y = v_s + \frac{(v_c - v_s)}{r}\sqrt{r^2 - y^2}$$

$$v_m = \tfrac{2}{3}v_c + \tfrac{1}{3}v_s$$

$$v_s = .615\,v_m$$

$$v_c = v_s = .577\,v_m$$

Substituting these in (1) and integrating:

$$E = \frac{\pi w r^2}{g}\left[\tfrac{1}{2}v_s^2 + v_s^2(v_c - v_s) + \tfrac{3}{4}v_s(v_c - v_s)^2 + \tfrac{1}{4}(v_c - v_s)^3\right]$$

$$= 0.526\,\frac{\pi w r^2 v_m^3}{g}$$

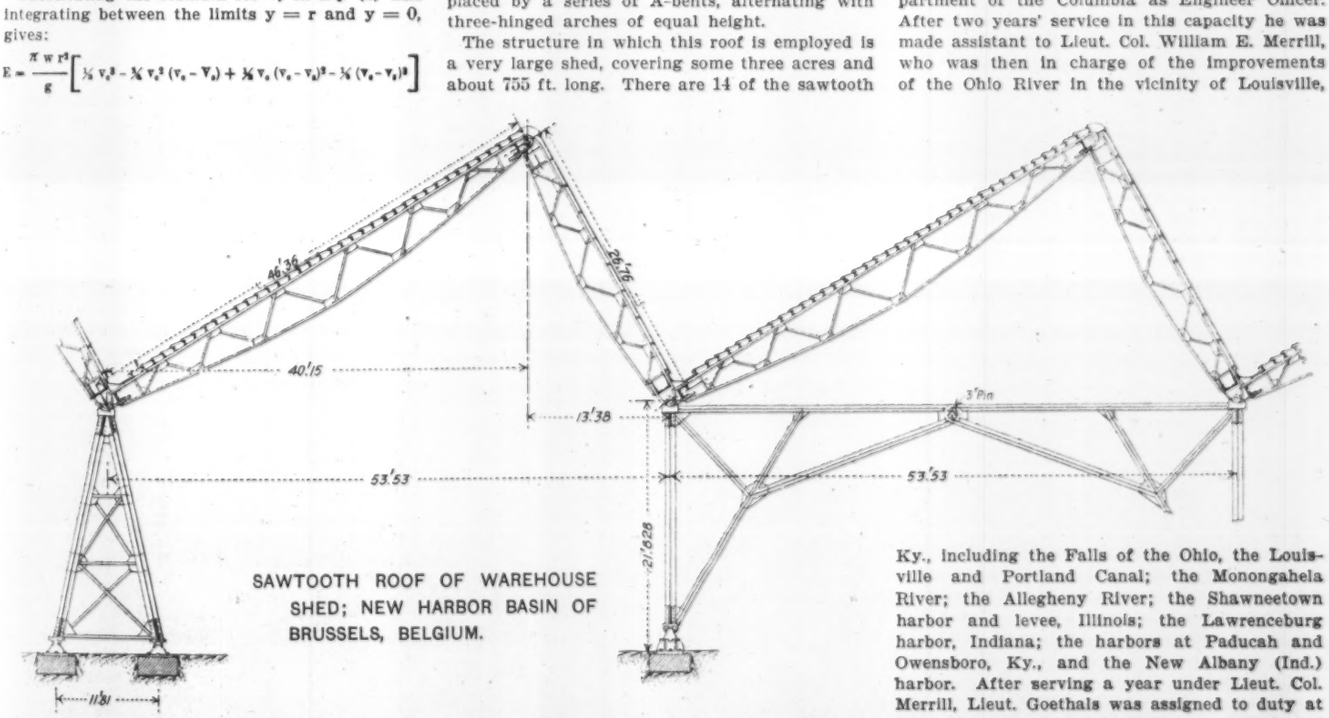
$$= 1.052\,\frac{W v_m^2}{2g} \qquad (4)$$

Equations (3) and (4) show that the true energy is about 4 or 5% in excess of that obtained by the ordinary method of calculation when applied to the flow in pipes. This is too large to neglect in the experiments in question. Similar investigations might be profitably made in connection with jets from the nozzles of impulse turbines, passages of centrifugal pumps, open channels, rivers, etc., in cases where the required accuracy demands it. In any case, it may aid in the interpretation of results to know that energies by the ordinary method are uniformly small.

A NOVEL SAWTOOTH WAREHOUSE ROOF AT BRUSSELS.

Recent harbor improvements at Brussels, Belgium, include a great receiving and shipping warehouse on the bank of the harbor basin. An annex shed of this warehouse has a steel-frame roof of strikingly novel design, which we herewith illustrate [after "Le Genie Civil" of Jan. 12, 1907]. The roof is of the sawtooth form. Insted, however, of using trusses to form the sawtooth, as is usual, a three-hinged arch is employed; each of the two rafters is a lattice-girder pinned at its foot to the supporting framework, the two girders being pinned together at the top. The necessary provision for taking up the arch thrust in the supporting structure led to a further novelty here. The columns and occasional bracing of the usual shed-roof are replaced by a series of A-bents, alternating with three-hinged arches of equal height.

The structure in which this roof is employed is a very large shed, covering some three acres and about 755 ft. long. There are 14 of the sawtooth spans in the length of the building, each span 53.53 ft. between centers of end pins. The spacing of arches in the transverse direction is not stated, but is evidently moderate, as the purlins are shallow I-beams and channels. The angle at the peak of the sawtooth is approximately 90°. A locked tile covering is used on the flat side, and glass on the full height of the other; the width of the gutter is quite small, about 25 ins.



SAWTOOTH ROOF OF WAREHOUSE SHED; NEW HARBOR BASIN OF BRUSSELS, BELGIUM.

The detail design of the structure is not remarkable. All connections are riveted except the end and center joints of the sawtooth arches and the center joint of the supporting arches, which are pin points. The supporting arches and A-bents rest on cast-iron rocker shoes. The arch nature of the sawteeth permits free expansion, so that no slip-points are necessary. The nature of the lateral bracing is not apparent. The posts of the A-bents and all members of the supporting arches are composed of four angles riveted back to back in cross-shaped arrangement. The top chord of each member of the sawtooth arches is made of two 3½-in. channels back to back, while the bottom chord consists of two 4 × 3 × ⅝-in. angles. The pin-socket pieces at the base of the sawtooth members are cast shoes bolted to the tops of the A-bents and arch-posts.

THE ARMY ENGINEERS, WHO SUCCEED CHIEF ENGINEER STEVENS, OF THE PANAMA CANAL.

As noted in our last issue, army engineers have been selected to succeed Chief Engineer Stevens, of the Panama Canal organization. Major George W. Goethals will act as Senior Engineer and Chairman of the Commission, while Major David Du B. Gaillard and Major William L. Sibert will be his assistants.

MAJOR GOETHALS.

Major Goethals was born in New York. He graduated from West Point, June 12, 1880, as second ranking member of his class. It is interesting to note in this connection that Major Goethals was only second to Capt. O. M. Carter, who was dismissed from the army a few years ago and ended his military career in Fort Leavenworth military prison, for his connection with frauds in the river and harbor improvements at Sayannah, Ga. Soon after graduation Lieutenant Goethals (he had been commissioned second lieutenant, corps of engineers) was assigned to the battalion of engineers at Willet's Point, N. Y., where he remained for two years. On June 15, 1882, he was made first lieutenant, and five months later was assigned to the Department of the Columbia as Engineer Officer. After two years' service in this capacity he was made assistant to Lieut. Col. William E. Merrill, who was then in charge of the improvements of the Ohio River in the vicinity of Louisville, Ky., including the Falls of the Ohio, the Louisville and Portland Canal; the Monongahela River; the Allegheny River; the Shawneetown harbor and levee, Illinois; the Lawrenceburg harbor, Indiana; the harbors at Paducah and Owensboro, Ky., and the New Albany (Ind.) harbor. After serving a year under Lieut. Col. Merrill, Lieut. Goethals was assigned to duty at West Point, as Assistant Professor of Civil and Military Engineering. Three years later he was appointed Principal Assistant Professor of these subjects, which position he held for one year. After two months' service as assistant to Major Lockwood and Lieut. Col. Merrill, he was appointed assistant to Lieut. Col. Barlow, Oct. 23, 1889.

It was on March 18, 1891, that Lieut. Goethals

was given his first great engineering task, when he was placed in charge of the improvement work of the Tennessee River, below Chattanooga. His work at Chattanooga consisted of dredging and removing obstructions in "The Suck," a portion of the river about nine miles long; the building of a canal 14.5 miles long, 70 to 120 ft. wide and 6 ft. deep, around the Big Muscle Shoals, the canal having nine locks each 60x300 ft.; the building of an aqueduct 60 ft. wide and 900 ft. long over Shoal Creek; the construction of a canal 1½ miles long, with two locks, around Elk River Shoals; the building of a canal three miles long, with two locks, around Little Muscle Shoals and the building of a canal 7.8 miles long, 150 ft. wide and 7 ft. deep around Colbert and Bee Tree Shoals, with a combined lock at the lower end of the canal and a guard lock at its head, the locks each being 80 x 350 ft.

Lieut. Goethals was advanced to Captain, Corps of Engineers, on Dec. 14, 1891, and on Oct. 8, 1894, was called from his work at Chattanooga, to Washington to act as Assistant to Chief of Engineers Casey. He retained this position until May 26, 1898, when he was commissioned Lieutenant-Colonel of Volunteers and sent to Cuba as Chief Engineer of the First Army Corps. After five months' service in the field he returned to the United States, and was again assigned to duty at West Point as Instructor of Practical Military Engineering in command of the engineering company and in charge of water-works. He was commissioned Major, Corps of Engineers, Feb. 7, 1900, and on Aug. 28, 1900, was transferred from West Point to Newport, R. I., where he was placed in charge of fortifications and river and harbor work. While at Newport he had charge of the improvement of Taunton River, Mass., Sakonnet and Pawtucket Rivers, Providence River and harbor, Narragansett Bay and Green Jacket Shoal at Providence, R. I.; the construction of bridges across Buttermilk Bay, Wareham, Swifts, Acushnet, Monument and Seekonk Rivers and the reconstruction of other bridges. and the improvement of the harbors of Hayannis, Nantucket, New Bedford, Vineyard Haven, Fall River, Newport and Block Island. After three years' service at Newport, Major Goethals was called to Washington and made a member of the General Staff of the Army, from which position he was appointed to his new office.

MAJOR GAILLARD.

Major Gaillard was born in South Carolina. He graduated from West Point on June 15, 1884, being commissioned Second Lieutenant, Corps of Engineers. He was at once attached to the battalion of engineers at Willet's Point, N. Y., where he remained for three years, when he was made assistant to Captain Black, officer in charge of river and harbor work in Florida. He was promoted to First Lieutenant, Corps of Engineers, Oct. 22, 1887, and in November, 1891, was made a member of the International Boundary Commission, United States and Mexico. He remained a member of this commission for five years, but from February to October, 1895, he was assigned to duty at Fort Monroe as Assistant in local charge of defenses.

On Oct. 25, 1895, he was appointed Captain, Corps of Engineers, and assigned to duty at Washington as Assistant in charge of the Washington Aqueduct. He served in this capacity until May 3, 1898, except from August to November, 1896, when he was engaged in the survey of the Portland Canal, Alaska. After serving a short time as Engineer Officer on the staff of Maj.-Gen. J. F. Wade, U. S. N., he was commissioned Colonel U. S. V. Engineers, June 7, 1898, and sent to Cuba in command of the Third Volunteer Engineers. After a year's field service Colonel Gaillard was transferred to Washington as Assistant to Lieut.-Col. A. M. Miller, in connection with the Washington Aqueduct. Four months later he was made Assistant to the Engineer-Commissioner of the District of Columbia.

On March 9, 1901, he was placed in charge of the river and harbor works at Duluth, Minn., where he remained until June 6, 1903, when he was assigned to special duty in connection with the General Staff Corps at Vancouver Barracks, Wash. After some six months' service at Vancouver he was sent to St. Louis, Mo., as Assistant Chief of Staff of the Northern Division. He was commissioned Major, Corps of Engineers, April 23, 1904, and on November 13 of the same year was transferred to Washington as Student Officer at the Army War College. He held this position until March 23, 1905, when he was detailed to duty on the General Staff Corps. Since Oct. 9, 1906, he has been stationed at Havana, Cuba, as Assistant to the Chief of the Staff of the Army of Cuban Pacification.

MAJOR SIBERT.

Major Sibert was born in Alabama. He entered West Point in the same class as Major Gaillard, graduating on June 15, 1884. He was commissioned Second Lieutenant, Corps of Engineers, and assigned to duty with the battalion of engineers at Willet's Point, N. Y. After three years' service at Willet's Point he was made Assistant to Major Stickney, and on April 7, 1888, he was made a first lieutenant of the Corps of Engineers. He was appointed Assistant to Major Lockwood Feb. 25, 1888, as Recorder of the Board of Engineer Officers on the proposed bridge between Cincinnati, O., and Newport, Ky. In November of the same year he became a member of the board on bridge across the Green River, below Lock No. 1.

From December, 1888, to August, 1892, he was located at Bowling Green, Ky., in local charge of improvements on the Green and Barren rivers. The following two years he was stationed at Detroit, Mich., as assistant to General O. M. Poe, in local charge of the construction of one-half of the ship canal connecting the waters of the Great Lakes. He was then transferred to Little Rock, Ark., and placed in charge of a river and harbor district. On March 31, 1896, he was commissioned Captain, C... of Engineers, and in September, 1898, was ... to Willet's Point, N. Y., in command of C... any B, Engineering Battalion, as Instructor ... Civil Engineering. He remained there until ... 5, 1899, when he was sent to Manila, in ... and of Company B, Second Division, Eighth ... ps. He returned to the United States after ... ar's service in the Philippines, and was ... to Louisville, Ky., in charge of river and ... bor works. A year and a half later he was ... ns- ferred to Pittsburg and placed in charge ... the river and harbor works of that district ... ich. position he has since held. He was ... is- sioned Major, Corps of Engineers, on A... 23, 1904.

A CONVENIENT METHOD OF PLATE GIRDER ER... ION.

The accompanying photographs illustrate a method of plate-girder erection which has been devised by Mr. C. L. Ketchum, Bridge F... man for the St. Louis & San Francisco R. R. and used in many cases by that company.

The two views show, without much additional description, the manner in which the girders are placed. The timber frame derricks are built on ordinary flat cars, and the girder bridge, which has been riveted up complete, is lifted up between the two derricks from a side track near the old bridge. The cars and girders are then run into place and the girders lowered, as shown in Fig. 2.

The photographs here given show the placing of a 75-ft. deck girder at Little Warrior River, in Alabama, where 150-ft. deck trusses were replaced each by two 75-ft. deck-girders. The deck spans being somewhat wider it was possible, by taking out the lateral bracing, to place the complete girder spans inside the old deck trusses.

We are indebted for the photographs and information to Mr. C. D. Purdon, M. Am. Soc. C. E., of St. Louis.

AIR LEAKAGE IN CONDENSER SYSTEMS.

The greatest care is necessary in the design, construction, and maintenance of a condenser system to keep it free from air leakage. The leaks are inward, therefore invisible and hard to locate.

The application of two or three coats of paint on clean surfaces will eliminate many of the leaks in exhaust pipe lines, but there still remain several places for air leaks which are not so easy to remedy. The stuffing boxes on the rods and exhaust valve stems of the low-pressure cylinder are apt to leak. This trouble, however, can easily be eliminated by using double metallic packing on both rods and valve stems, and piping the steam from the receiver to the space between the two sets of packing, thereby forming a steam seal on the rod.

Another source of air leakage into the condensing system is through the water supply. The stuffing boxes on the pump should always be

Fig. 1. Girders in Place on Top of Old Trusses.

Fig. 2. Lowering Girders Into Place.

ERECTING A PLATE GIRDER BETWEEN OLD DECK TRUSSES, LITTLE WARRIOR RIVER, ALA., ST. L. & S. F. R. R.

...l with water, and all joints on the suction ...must be made up tight. The line should be ...fully painted before burying it in the ground. ...higher the suction life the more care should ...rcised in this work, because all air drawn ...ough the suction line, which is subjected ...cuum, is discharged directly into the con... The fact that the pipe may be buried ...al feet under ground does not protect it ...air leakage.

...further source of air being drawn into the ...nsing system is with the water through the ...ion line of the pump. All suction lines ...ld be submerged not less than 6 ft., and ...e if possible. The end of the suction pipe ...ld be increased to at least twice the diameter ...the pipe to reduce the velocity of the water ...ering the line.

...ese suggestions are offered by the Allis-...almers Co., of Milwaukee, Wis.

NOTES FROM ENGINEERING SCHOOLS.

ALTOONA HIGH SCHOOL.—The industrial department of the school has received a donation from the Pennsylvania R. R. in the shape of a complete drawing room, wood-working shop, pattern shop, forge shop, machine shop and foundry equipment. This gift places the school in the front rank of manual training schools of the country, as far as equipment is concerned. A four-year course will be given, including thorough instruction in mechanical and architectural drawing, machine shop and foundry practice, pattern making, forging, etc.

The shops were laid out by the railway company's engineers, in conjunction with the Director of the Industrial Department of the school, Prof. A. E. Karlson. All of the machines, which are of the latest design, are direct-driven by electric motors, there being no belting or shafting in the shops. The shops have been laid out with the idea of illustrating modern practice, and will be used in teaching for that purpose.

It is the expectation of the railway company that by establishing an industrial department in connection with the High School it will be able to secure youths to enter its shops as apprentices who are well equipped to take up the work.

A VERDICT ON THE NEW YORK CENTRAL WRECK at Woodlawn, in the Bronx, New York City, was brought in by a coroner's jury on March 4. The verdict finds culpable negligence on the part of the railroad and divides the responsibility between the operating and construction departments. The Coroner, in spite of the fact that the jury failed to specify any particular official as responsible, held the entire board of directors of the railway, together with the president, for the action of the Grand Jury. This order of the Coroner was, however, afterward modified and the revised finding holds "that there is sufficient cause to believe the said corporation guilty of the crime of manslaughter in the second degree."

This is the accident in which the newly organized train of the electric service of the N. Y. C. & H. R. R. R., drawn by two electric locomotives, was derailed while rounding a 3° curve, superelevation of 4½ ins., with 100-lb. rails single spiked to ties every 20 ins., at a speed testified to as between 45 and 60 miles per hour. The following paragraphs from the finding of the Coroner's Jury are interesting:

That the said train, made up as it was shown to have been, was running at a speed in excess of what has been proved to be safe for such a train on a track laid to the existing curvature at this point, rails of which were fastened to the ties in the manner these were proved to have been fastened, and the superelevation to be as has been proved of 4½ ins. That the running of said train at unsafe speed over said track exerted sufficient lateral pressure on the outer or easterly rail to cut off or shear the heads of the spikes holding said rails to the ties, thus permitting its displacement and the resultant accident.

The jury further recommended that railways be required to reinforce all fastenings of the outer rail on all curves by "additional spikes, rail bracers or increased superelevation," and that until such reinforcing has been accomplished the speed of all trains be reduced while rounding such curves to the so-called equilibrium speed. As a result of this latter recommendation an order has been made on the New York Central lowering the speed of all trains within the Electric Zone to a speed not exceeding 45 miles per hour on a straight track and 35 miles per hour on curves.

The accident is still under investigation by the State Railroad Commission.

THE BATTERY TUNNELS UNDER THE EAST RIVER recorded another step toward completion when on March 1, 1907, the south headings met. The north tunnel was holed through on Dec. 14, 1906. The pair of tunnels carry the Rapid Transit subway from Manhattan to Brooklyn. Work was begun late in 1902 by the New York Tunnel Co., sub-contractor under the Rapid Transit Subway Construction Co.

TWO DERAILMENTS AND A COLLISION contributed to the list of railway accidents during the past week. A derailment occurred on the Baltimore & Ohio Ry., near Connellsville, Pa., on the evening of Feb. 28, a west-bound passenger train being involved. It is noteworthy because due to causes similar to those which wrecked the 18-hour train of the Pennsylvania R. R. at Mineral Point, Pa., on Feb. 23. Some part of the engine mechanism dropped to the track and derailed the train, the cars piling up over the engine after a trip of several hundred feet over the roadbed. The engine runner was killed in the wreck. The other derailment occurred on the evening of March 2 on the West Shore R. R. in the tunnel through the Palisades at Haverstraw, N. Y., where a southbound through passenger train was derailed by a broken rail, according to the company's statement. No one was killed. A collision took place on the New York, New Haven & Hartford R. R., near Naugatuck, Conn., in the early morning of March 2. A southbound special passenger train ran into a north-bound accommodation train, both trains running at fair speed. Five persons were killed.

A DYNAMITE MAGAZINE EXPLODED in the night of March 2-3 at Homestead, N. J., at the west portal of the Bergen Hill Tunnel of the Pennsylvania R. R. extension to New York City. Although the concussion was felt over a large territory, according to some reports more than 50 miles away, yet no one was killed and only two or three persons were injured. Many houses in the vicinity of the magazine were damaged, and several small buildings belonging to the construction plant of the tunnel were destroyed.

A GAS EXPLOSION in the Holden mine of the Lackawanna Co., at North Taylor, Pa., March 2, burned 26 men, eight fatally. The explosion wrecked the air passages, making it impossible for rescuing parties to enter the mine until repairs were made. A similar explosion in the Woodward mine of the same company, at Kingston, Pa., killed two miners and injured five others.

THE NEW PHILADELPHIA RAPID TRANSIT LINE was opened to traffic on Monday morning, March 4. The portion put into service extends from 69th St. east to 15th and Market Sts.; the larger part of this is on elevated structure, only about half a mile at the eastern end being in subway. A general description of the plans for construction was given in our issue of Dec. 29, 1904, p. 585.

THE EXTENSIVE IMPROVEMENTS on the Philadelphia, Wilmington & Baltimore division of the Pennsylvania R. R., at Havre de Grace, Md., which have been in progress for three years past, have now been completed. Most important of these is the new deck bridge over the Susquehanna which replaces the old through truss bridge that had become too light for heavy train service. The new bridge is located about 150 ft. up stream from the old one. It consists of 17 deck spans and a through draw span. Its total length is nearly a mile. The piers are of Allegheny Mountain sandstone with concrete backing and granite coping from Port Deposit. Part of the piers were built with open cofferdams and part rest on piles, but most of them had to be put down with pneumatic caissons. The greatest depth of foundation is 76.8 ft. below tide. The total material in sub and superstructure is 44,369 cu. yds. of masonry and 20,230,000 lbs. of iron and steel. Improvement of grades and curvature and removal of grade crossings, with an elevated masonry viaduct through the town of Havre de Grace, have also been made, extending over a distance of 5½ miles, and requiring 30,000 cu. yds. of masonry and 745,000 cu. yds. of excavation.

THE CHICAGO TUNNEL SYSTEM for handling freight, mails, etc., will probably soon be doing a large freight business, as it is reported that contracts have been made with 26 railways for the handling of their freight between the business district and the several freight stations. There are now about 30 miles of tunnel with narrow gage tracks operated by electric motors, and mails are now carried in this way between the railway stations and the post-office. Large establishments have spur tracks built into or beneath their basements, and six stations for the use of small shippers are being established in the business district. These are served by elevators. The tunnel system is owned by the Chicago Subway Co., in which the railways are financially interested.

SHIPS LOST AT SEA during 1906 are summarized by the Bureau Veritas as 29 steam vessels and 59 sailing vessels. In addition ten steamships were condemned and scrapped, and 23 sailing vessels. The principal cause of loss was stranding, which accounted for 18 steamships and 43 sailing vessels; 4 of each kind foundered, 3 steamships were lost by collisions, 4 steamships were destroyed by fire, and 6 sailing vessels were abandoned. Minor accidents were mainly collisions; 47 sailing vessels and 121 steamships being damaged in this way. Fire damage is by far heaviest for steamships, only two sailing vessels reporting fire damage, while 25 steamships were damaged by fire in addition to four destroyed by fire.

A NEW PASSAIC VALLEY SEWERAGE SCHEME has been formulated and a bill authorizing its execution by and under the direction of the existing Passaic Valley Sewerage Commission has been introduced in the New Jersey legislature. The bill provides that any municipality or combination of municipalities in the lower Passaic Valley may petition the sewerage commission to make plans and estimates of the cost of intercepting and trunk sewers and necessary accessory works. After the commission has fulfilled the request and reported to the several municipalities, the latter may enter into a contract with the commission for the construction of the contemplated works. The several municipalities are to raise funds to meet the expense of the joint sewerage system in proportion to the actual taxable valuation of the real estate and personal property in each municipality, as returned in 1907. The contemplated works would be operated as well as constructed by the commission, and the cost of maintenance and operation would be distributed among the several municipalities in proportion to the volume of sewage contributed by each. A very important provision of the act is the prohibition of the direct or indirect discharge of "any sewage or other polluted matter into the waters of the Passaic River" between the Great Falls in Paterson and the mouth of the river, or into any tributaries of the river between those points, after Dec. 12, 1912. This prohibition applies to "every municipality, corporation and individual." In case some municipalities do not enter the joint disposal scheme, their time for stopping the discharge of sewage into the river or its tributaries will be extended for two years after the completion of the joint scheme, provided those works are not in operation by Dec. 12, 1910. It is understood that this act has been agreed upon by the representatives of the cities of Newark and Paterson, in accordance with the understanding some time ago that Paterson should have an opportunity to secure and report on an independent sewage disposal scheme. The act provides that in case the city of Paterson joins in the construction of a trunk sewer, it shall be reimbursed to the extent of $8,000 for plans, reports, etc., which it has secured, those plans to become the property of the commission and the sum named to be included in the cost of the joint works. The report on sewage disposal for Paterson made in 1906 by Hazen & Whipple was abstracted in Engineering News of Aug. 16, 1906.

ENGINEER'S ESTIMATES on cost of highway improvement in the Eastern Division of the New York State Engineer's Office for the season of 1906 show a remarkably small variation from the lowest bids by contractors. On 87 bids for 350.6 miles of highways the total of lowest bids received aggregated $2,897,381.04, as against total revised estimates by the engineers of $2,921,278.08, a variation of bids from estimates of but 0.8%. Of the 350.6 miles in 87 different localities, the bids received for 182.4 miles (or over 50%) were within 5% of the estimates, and the bids for 333.5 miles (or over 95%) were within 15% of the estimates. Mr. C. W. Trumbull was Division Engineer of the Eastern Division and Mr. D. W. Robbins was Resident Engineer in charge of the Highway Office.

PERSONALS.

Mr. R. B. Van Horne has been appointed General Manager of the Cuba Ry., with headquarters at Chamaguay.

Mr. H. E. Stevens has been appointed Bridge Engineer of the Northern Pacific Ry., with headquarters at St. Paul, Minn.

Mr. William A. Lathrop has been elected President of the Lehigh Coal & Navigation Co., to succeed Mr. Lewis A. Riley.

Mr. J. F. Murphy, a trainmaster on the Missouri Pacific Ry., has been appointed Superintendent of the Memphis Division.

Mr. W. A. Garrett, First Vice-President of the Seaboard Air Line Ry., has been elected President, to succeed the late Alfred Walter.

Mr. T. B. Webber has been appointed Chief Engineer in Charge of the construction of the Morelia & Tacambaro R. R. to succeed Mr. O. V. Watkins, resigned.

Mr. John A. Fox, Trainmaster of the Cincinnati Division of the Chesapeake & Ohio R. R., has been promoted to be Assistant Superintendent of the Kentucky Division.

Mr. William Fripp, Superintendent of the West Shore R. R., River Division, has been appointed General Superintendent of the Boston & Albany R. R., to succeed Mr. J. B. Stewart.

Arthur Arton Hamerschlag, Director of the Carnegie Technical Schools of Pittsburg, Pa., was honored Feb. 22, by Lehigh University conferring upon him the honorary degree of Doctor of Science.

Mr. T. H. Matson, Assistant Engineer in the Construction Department of the Memphis & Chattanooga Ry., has resigned to accept a position in the Maintenance of Way Department of the Southern Ry.

Mr. J. E. Roemheld, President and Director of the Roemheld & Gallery Co., Contracting Engineers, of Chicago, Ill., has resigned and opened an office in the Security Building, Chicago, as a Contracting Engineer.

Mr. A. W. Jones has been appointed Assistant Chief Engineer of the South & Western Ry., with office at Johnson City, Tenn. Mr. Charles L. Ruffin has been made Division Engineer, with office at Clinchport, Va. He succeeds Mr. A. W. Jones, transferred.

Mr. F. E. Styner has resigned as General Manager of the Mexican Central Ry. Mr. D. F. Bucher, formerly Superintendent of Transportation, has been appointed General Superintendent, and for the present will attend to the duties of the general manager's office.

Mr. Philip H. McMillan, Secretary, has been elected President of the Detroit & Cleveland Navigation Co., to succeed the late William C. McMillan. Mr. A. A. Schantz, General Superintendent of the company, has been elected General Manager, and his former office abolished.

Mr. Harry S. Norris, Agent of the Union Tank Line Co., a subsidiary company of the Standard Oil Co., has been appointed Superintendent of the New York Transit Co., another subsidiary company of the Standard Oil. He will be in charge of the properties in the Buffalo Division.

Mr. Thomas Richardson, formerly connected with Westinghouse, Church, Kerr & Co., has been made head of the Drafting Department of W. S. Barstow & Co. His assistant in charge of structural steel design is Mr. Harold S. Richmond, also formerly connected with Westinghouse, Church, Kerr & Co.

Mr. Eberhard J. Wulff, County Engineer of Westchester County, N. Y., and Mr. Walter E. Stockwell, formerly connected with the United States Engineer's Office, at Cape Vincent, N. Y., have formed a partnership under the firm name of Eberhard J. Wulff & Co., Consulting Engineers, National Bank Building, Tarrytown, N. Y.

Mr. Joseph Bucklin Bishop, Secretary of the Isthmian Canal Commission, will now have exclusive charge of the affairs of the Commission at Washington, owing to the retirement of Chairman Shonts and Mr. W. L. Pepperman, Chief of Office. He will be assisted by Mr. Rufus A. Lane, Assistant Secretary of the Commission.

Mr. Herman F. Ball, Vice-President of the American Locomotive Automobile Co., has been elected Vice-President in charge of mechanical engineering and designing, of the American Locomotive Works. He succeeds Mr. James E. Legue. Mr. David Van Alstyne, Superintendent of the Brooks plant of the Locomotive Company, has been promoted to Vice-President in charge of manufacture. Both of these officials will have their headquarters at 111 Broadway, New York City.

Obituary.

J. C. Guilford, a well-known civil engineer and contractor of the South, dropped dead at Chattanooga, Tenn., Feb. 25. He was the promoter of the Great Lick dam on the Tennessee River below Chattanooga.

Charles Henry Vansant, Contracting Engineer for the Berlin Construction Co., died March 1. He was a graduate of Lehigh University, class of 1895, and was formerly employed by Mr. Field, a civil engineer and architect of Newark, N. J., and later an inspector for the New York Rapid Transit Commission.

John Donald Maclennan, M. Am. Soc. C. E., died at New York City Feb. 26, of heart disease, aged 50 years. He was one of the engineers employed in the recent investigation of the Philadelphia filtration contracts, and also acted as receiver for the contractor who had the contract for building the Washington filtration plant. In this connection he finished building the Washington plant.

John Watson Bacon, M. Am. Soc. C. E., a former State Railroad Commissioner of Connecticut, died at his home in Danbury, Conn., Feb. 27, aged 79 years. He was born at Hartford, Conn., in 1827, and graduated from Trinity College in 1846. He then became principal of an academy at Essex, Conn., but shortly resigned and took up the study of law. Two years later he abandoned law and took up civil engineering, and was employed on the first surveys of the New York & New England R. R. Later he became Superintendent of the division between Providence, R. I., and Waterbury, Conn. In 1869 he was appointed Superintendent and Chief Engineer of the Danbury & Norwalk R. R., and in 1877 was appointed State Railroad Commissioner.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 19-21. Annual Meeting at Chicago, Ill. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago, Ill.

IOWA ELECTRICAL ASSOCIATION.
April 18-19. Annual Meeting at Clinton, Iowa. Secy., L. B. Spinney, Iowa State College, Ames, Iowa.

THE AMERICAN RAILWAY ASSOCIATION.
April 24. Annual Meeting at Chicago. Secy., W. F. Allen, 24 Park Pl., New York City.

BOSTON SOCIETY OF CIVIL ENGINEERS.—The annual dinner of the society will be held at Hotel Vendome, Boston, Mass., March 12, at 6.30 p. m.

QUEBEC ARCHITECTS' ASSOCIATION.—At the recent annual meeting the following officers were elected: President, Mr. R. P. Lemay; First Vice-President, Mr. D. R. Brown; Second Vice-President, Mr. Amos; Secretary, Mr. E. Varnier; Treasurer, Mr. J. R. Gardiner.

ILLUMINATING ENGINEERING SOCIETY.—A meeting of the New York Section will be held in the Edison Auditorium, 44 West 27th St., New York City, March 8 at 8.15 p. m. Papers on "The Lighting of Large Office Spaces" will be read by Messrs. Wm. T. Clarke, S. B. Burrows, E. A. Norman and Charles Cohn.

NEW ENGLAND WATER-WORKS ASSOCIATION.—A meeting of the association will be held at Hotel Brunswick, Boston, Mass., March 13. The papers to be presented are as follows: "Some New Facts Relating to the Use and Waste of Water," Mr. William S. Johnson; "Description of the Plant at Peabody, Mass., Involving Construction of Tunnel, New Reservoir, New Pumping Station, and High-Duty Worthington Pump," Mr. F. A. Barbour.

AMERICAN ELECTROCHEMICAL SOCIETY.—The regular meeting of the New York section was held at the Chemists' Club, 108 West 55th St., New York City, Feb. 26. The paper of the evening on "The Relative Cost of Power From Water, Steam, Gas and Oil," was read by Prof. Charles E. Lucke, of the Mechanical Engineering Department of Columbia University. The paper and the discussion which followed its reading emphasized the fact that the selection of a power and the cost of developing such power were largely dependent upon the natural resources of the place in question, local conditions and load factor.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK held a regular meeting in the Engineering Societies' Building on Feb. 27, President George S. Rice in the chair. After a short business meeting Mr. Deforest H. Dixon, Secretary of the Turner Construction Co., presented a paper on "Construction Details of Reinforced Concrete Work." Mr. Dixon said that the many recent failures in reinforced concrete were in most cases due to skimped design plus poor material and workmanship. In order to arrive at the best work the five requisites are (1) good plans, (2) good organization of force, (3) good material, (4) steel in proper position, (5) good concrete. Mr. Dixon followed his paper with some views showing various kinds of reinforced concrete construction which have been built by the company he represents.

DOMINION LAND SURVEYORS' ASSOCIATION.—This association, which was founded during the rush to the West in 1883, but which has been defunct for several years, was reorganized at a well-attended meeting in Carnegie Library auditorium, Ottawa, on the evening of Feb. 27. The primary aim of the association is to see that proper regulations are made by the government when passing new bills. Many of the bills for work in the new western country now have no clauses inserted stating the conditions under which the work must be done. There are certain surveys which are only legal when carried out by a certified Dominion Land Surveyor, but often when no definite requirements are inserted in the act, an unregistered civil engineer is employed. The association will endeavor to see that the law is explicitly referred to in each new bill.

Mr. E. Devill, Surveyor General for the Dominion, gave a brief address referring to the necessity of watching the legislature, which often allows bills to slip through adverse to the surveyors' interests. The officers elected are: Honorary Patron, Mr. E. Deville; Hon. President, Dr. W. F. King; President, Mr. E. W. Hubbell; Vice-President, Mr. R. E. Young; Secretary and Treasurer, Mr. E. D. Phillips; Executive Committee, Dr. O. J. Klotz, Mr. Thomas Shanks and Mr. F. D. Henderson.

NEW YORK ELECTRICAL SOCIETY.—The 265th meeting of the society, on Feb. 27, was the first held in the new Engineering Societies' Building, 39 W. 39th St., New York City. An office in the building has been rented, and the use of one of the assembly rooms secured for the regular meetings. President G. H. Condict, in his opening remarks made reference to this fact, and to the increased expenditure it entailed, and he urged that strong efforts be made to increase the society's membership (at present about 700) in order to supply a needed increase in funds.

Prof. H. B. Smith, of Worcester Polytechnic Institute, Worcester, Mass., delivered an illustrated address under the title "Power Transmission Voltages of To-day and To-morrow." He introduced the subject by a reference to the present great consumption of electric current in which the United States far leads all other countries, and the increase of this consumption; and to one or two existing and proposed long-distance transmission projects. Mr. R. B. Mershon's calculations of economical voltage for the transmission of various powers over various distances were cited to show that higher tensions than now are possible will be demanded for future long-distance work. Experiments with high-tension current were begun at Worcester in 1893. Since that time four or five transformers, capable of delivering current at pressures up to 300,000 volts normally, have been built there; and a 1,000-KW., 120,000-volt transformer has been built from designs made by the speaker. They have been used for testing insulation, investigating sparking distances, studying the potential distribution between wires, and similar research work. The speaker advanced a formula for sparking distances between needle points, deduced from his experiments and believed to be approximately true:

$$K\text{-}V. = 21.5 + 10.13\,d$$

where d is the distance between points in inches and K-V. is the spark pressure in kilovolts. The experiments on potential distribution between wires gave results agreeing fairly well with theory. It is observed that at a certain voltage, depending on the size of conductor, the surface layer of air breaks down with a brush discharge, after which there is a leakage and increased capacity loss. Attempts at separating these losses have not yet succeeded.

The speaker showed a large number of photographs of high-tension spark-arcs, 6 to 32 ins. long, and of discharges in testing line-insulators. Some views of various pole-line constructions and two micro-photographs of insulator porcelain showing hollows or pores ended the address. Messrs. H. A. Lardner and G. H. Condict spoke briefly in discussion.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The 215th meeting was held at the Engineering Societies' Building, 33 West 39th St., New York City, March 1. Secretary Pope announced that the annual convention would be held at Niagara Falls, N. Y., the week of June 25. Three technical papers were read in abstract by the authors. The first paper, on "Alternating-Current Electrolysis," by J. L. R. Hayden, gave the results of extended experiments, which tended to show that alternating-current electrolysis varies from practically nothing to somewhat less than 1% of direct-current electrolysis; that it varies with the chemical character of the electrolyte; and that it generally increases with decrease of frequency and always with increase of soil temperature. Also that the superposition of a direct current equal to 3.80% of the alternating current, would give complete protection against electrolysis by the alternating current.

Mr. A. A. Knudson's paper on "Electrolytic Corrosion of Iron and Steel in Concrete" was also the statement of results of experiments, which showed that if iron imbedded in concrete was subjected to electrolysis the concrete deteriorated and cracked and the iron was corroded, but whether the destruction of the concrete was due to chemical, mechanical or electrical causes, the author did not attempt to say.

The last paper of the evening, by Mr. George I. Rhodes, on "Some Theoretical Notes on the Reduction of Earth Currents from Electric Railway Systems by Means of Negative Feeders," was a mathematical discussion of the subject, and showed that by the use of negative boosters and proper arrangement of negative feeders earth currents could be reduced to 1.2% of the original leakage.

In the discussion which followed the reading of these papers, Mr. Knudson's paper was severely criticized by Mr. F. N. Waterman as being incomplete and valueless. Mr. C. P. Steinmetz, however, thought that the experiments should be carried farther and the exact cause of the concrete deterioration be determined. Mr. Steinmetz also thought that the question of alternating-current electrolysis as regards effect on water and gas pipes is unimportant, but when it comes to the question of lead-covered cable no expense should be spared to protect it against electrolysis. Mr. J. W. Corning, Electrical Engineer of the Boston Elevated Ry. Co., briefly described an arrangement employed by that company on its Cambridge section of road, which he termed a three-wire system. This gives a reduction in return drop of 83%, while the leakage current is reduced 85% and the potential between track and underground pipes also reduced.